A STUDY OF LICHEN DISTRIBUTION ON SELECTED TREES IN EASTERN METROPOLITAN ATLANTA AS INFLUENCED BY THE CITY ENVIRONMENT

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LIST OF TABLES

LIST OF FIGURES

Figure | Page

TABLE OF CONTENTS

CHAPTER I

INTRODUCTION

A search of the literature reveals few studies on the lichen bionta of Georgia. Plummer and Moncrief (1964) studied lichens on granite flat rocks in the state. Platt and Amsler (1952) studied the growth rate of lichens on the bark of certain Georgia tree species. Skorepa (1968) collected lichens on standing trees in the Okefenokee Swamp and published the only checklist of lichens found in the state. At the present time the literature contains no report of lichens found on standing trees in an urban area of Georgia. Furthermore, the only reported study of lichens from an urban area in the United States, as far as I have been able to determine, is that of Brodo (1966) who studied lichens from the New York-Long Island area.

Lichenologists have long recognized that the lichen population of a city decreases from the outskirts of the city until a lichen desert is found near the city's center. An unresolved controversy exists as to the cause of this decrease in lichen population and diversity. The majority of investigators (LeBlanc, 1969; Hale, 1967; Pearson and Skye, 1965; LeBlanc and DeSloover, 1970; Brodo, 1966; and Barkman, 1969) believe that atmospheric pollution produced by the city's industrial processes and human activity, while not the sole reason, represents the principal causal factor responsible for the reduction in the lichen population. According to Brodo (1966), in 1951 Rydzak, on the other hand, proposes that it is the drought condition induced by the city's comparatively higher temperature and lower humidity that is detrimental to lichens in urban settings. Barkman (1958) reviewing the literature to that date feels that both factors affect the lichen population, with atmospheric pollution affecting lichens over a much greater distance than city induced drought. Up to the current time the scientific data reported seem to favor the fact that air pollution is indeed the major causal agent in the reduction of lichen species in urban areas. This, then, makes them ideal biological indicators of atmospheric pollution.

It was with this view of the state of the knowledge of the lichen bionta of Georgia and urban areas that the study reported here was initiated. The principal objectives of the study were as follows: (1) to provide a list of the lichen species found on standing trees in the Atlanta metropolitan area, and (2) to attempt to correlate this distribution of lichens with levels of atmospheric pollution in the city environment.

Fulfillment of the first objective will add to the general body of knowledge of lichens found in Georgia and provide a basis for a comparison of lichen populations from other environmental settings. The second objective will serve as a foundation for further investigations on atmospheric pollution level changes in metropolitan Atlanta and identify sites where high pollution levels prevail. Atlanta is an excellent location for a study of this nature because it is not yet so heavily industrialized or as old as those cities in which studies of this type have been made, namely, London, New York, Montreal, Belfast, and Munich. With this study as background the effects of future population increases and industrial expansion on lichens can be evaluated.

CHAPTER II

REVIEW OF LITERATURE

The study by Skorepa (1968) of lichens that occur on standing trees in the Okefenokee Swamp is the only report of such a study in Georgia. Skorepa (1968) studied the lichens of the Okefenokee Swamp and reported finding eighty-one species, 41% of which were crustose forms. He further indicated that although most of the species found were typical southern forms, the majority of the species recorded represented new records for Georgia.

Skorepa (1968) grouped the lichens found in the Okefenokee Swamp according to their apparent habitat preference. Four habitat preference categories were recognized. The categories and associated genera are as follows: (1) On the bark of cypress (*Taxodium distichum*) trees in full sun - *Buellia*, *Cladonia*, *Collema*, *Cyphelium*, *Lecanora*, *Leptogium*, and *Physcia*. (2) On bark of cypress trees in swampy areas - *Buellia*, *Parmeliopsis*, and *Usnea*. (3) On trunks of oak trees in open woods - *Buellia*, *Haematomma*, *Lecanora*, and *Lecidea*. (4) On branches of trees and shrubs in sunny places - *Parmelia* (4 species), *Ramalina*, and *Usnea* (3 species). Skorepa offers no suggestions as to the probable cause of this distribution and draws no conclusions in his paper.

Plummer and Moncrief (1964) studied the growth rates of lichens found on granitic flat rocks in Georgia. They reported that (1) smaller lichen thalli increase in size proportionally more than larger thalli, and (2) that, in general, lichen thalli show a greater increase in size during the period from July to December than at other times during the year. Plummer and Moncrief also investigated the effects certain fertilizer solutions had on the growth rate of lichen thalli kept on the roof of their laboratory. Results from this study indicated that potash apparently had a distinct nutrient value to the lichen thalli examined (*Parmelia conspersa* and *Dermatocarpon flerviatile*).

Platt and Amsler's (1952) report mentioned before was not published in the literature. Instead it was given as a paper at the 1952 annual meeting of the Georgia Academy of Science. Plummer and Moncrief (1964) state that Platt and Amsler had devised a method for studying lichen growth rates and succession on tree twigs by using dry weight-biomass analysis.

LeBlanc (1971) reports that as early as 1866 Nylander suggested that lichens could be used to indicate the purity of air. In spite of this early recognition of lichen sensitivity to air pollutants, until relatively recent, few studies of this nature were available. A controversy has existed, however, as to whether the detrimental effect noticed on lichens growing under city conditions is the result of pollution or the xeric environment of the city. According to Brodo (1966), Rydzak in 1958 suggested that the drought and low humidity conditions in a city, resulting from significantly higher temperatures and complete run-off of precipitation, were the causal reasons for lichens dying in and near cities. In addition, Rydzak (from Brodo, 1966) claims that no city has been studied where air pollution was great enough to cause any detrimental effects to lichens.

Brodo (1966), in his study of the New York-Long Island area, based on (1) the lichen distribution along a transect, (2) a comparison of the present day lichen distribution with older distributions, and (3) transplant studies along the transect, tends to agree with Rydzak's theory that city induced xeric conditions is causal agent responsible for the disappearance of lichens in cities. His reason for this belief is that corticolous lichens (those found growing on trees) are limited in their distribution to trees growing in humid localities. Evidence to the contrary has begun to appear in the literature.

Other authors suggest that atmospheric contaminants, particularly sulfur dioxide and particulate matter, cause lichens to die in cities. Pearson and Skye (1965), in their experiments with lichen disks collected from unpolluted areas and kept in flasks contaminated with sulfur dioxide, conclude that the sulfur dioxide causes both morphologic and photosynthetic changes similar to those found in lichens collected from an industrial center in Sweden. The morphologic changes were noted from macroscopic examination and the photosynthetic activity was measured by the direct Warburg method. To further confirm their conclusions, that the atmospheric pollutant sulfur dioxide induced the changes and not the xeric conditions of the city, Pearson and Skye dried lichen discs for 4-1/2 to 6 months in their laboratory and then measured their photosynthetic activity. They reported that there was no significant difference eetween the photosynthetic activity of the dried lichens and that of freshly collected ones. These data indicate that drought may not be as important a factor as Rydzak and Brodo have asserted.

Hale (1967), in his excellent textbook on lichens, agrees that atmospheric contaminants are the major cause of the deleterious effects cities have on lichens. Hale states that lichen thalli exposed to sulfur dioxide are thinner and more discolored and have a lower photosynthetic rate than lichens which have been dessicated. Hale goes on to state that lichens kept dry in a sulfur dioxide free atmosphere can be revived after as long as three years and resume normal photosynthetic activity.

LeBlanc (1969) in his review of experimental data from his studies on lichens in three ecological areas, appears convinced that it is atmospheric contaminants, particularly sulfur dioxide, that causes lichens to die in cities and near industrial centers. LeBlanc (1969) studied an iron sintering plant that emitted large quantities of sulfur dioxide in the Wawa area of Canada. He used transect lines extending in all directions from the plant. It should be noted that the prevailing wind pattern in this area is off Lake Superior and since these winds would be moisture laden, a somewhat higher relative humidity would be created in the Wawa area. LeBlanc concluded that five zones of epiphytic vegetation (lichens and mosses) could be established on the basis of the concentrations of soil sulfate deposited from stack effluence. The zones recognized by LeBlanc are as follows:

Zone 1. Sulfate concentration everywhere more than 1.4 meg/100g; epiphytes absent.

Zone 2. Sulfate concentration between 0.9 and 1.4 meg/100g; 14 species of epiphytes in this zone.

Zone 3. Sulfate ooncentration between 0.9 and 0.7 meg/100g; 60 species of epiphytes were found in this zone.

Zone 4. Sulfate concentration between 0.4 and 0.7 meg/100g; 80 species of epiphytes were found in this zone.

Zone 5. Sulfate concentrations less than 0.4 meg/100g; because this zone was completely out of the polluted area no attempt was made

to collect all species present and only
79 were collected.

LeBlanc reports that in the direction of the prevailing wind the vegetation does not become characteristic of the region for a distance of 56 Km.

As a result of studies conducted by LeBlanc (1969) in Sudbury, a nickel-mining center in Ontario, he reported sulfur dioxide damage to epiphytes from plant effluence up to 40 Km away. By carefully examining data from 10 automatic sulfur dioxide recorders and comparing them with the number of epiphytes found near each station, LeBlanc concludes that the number of epiphytes at each recorder was inversely proportional to the quantity of sulfur dioxide recorded. Macro- and microscopic examination of one year transplants of lichens from unpolluted areas to recorder stations reveal the following changes: (1) a marked reduction in the thickness of the thallus of 2 species of lichens, (2) the formation of a thin layer of whitish crystalline and water insoluble compound on the surface, (3) an incipient to total plasmolysis in the algal symbiont, (4) chloroplast injury in the algal cells ranging from sporadic brown spots to complete disappearance of the green pigment, (5) the presence of oil globules in the algal cells, and (6) the formation of chlamydospore-like bodies by the fungal symbiont, especially in the lower cortex. LeBlanc believes that the changes noted as numbers 5 and 6 are due to stress exerted on the lichens by the unfavorable environment.

LeBlanc (1969), in his discussion of his studies in the Montreal area, admits to the lack of experimental proof that atmospheric contaminants in large cities are the causal agents in the disappearance of lichens. However, he suggests that the evidence indicated by the relationship of lichen well-being to their distance from pollution centers is sufficient to support his contentions that pollutants have a deleterious effect. LeBlanc concludes from his Montreal studies that (1) there exists a direct relation between the quality of the epiphytic vegetation and the location of heavy industries and residential centers, (2) the percentage of frequency of epiphytes in the area was greater as one moved from inner regions to outer regions, (3) fertility also seems to be affected by pollution (apothecia were lacking on *Physcia millegrana* in inner regions but present in increasing percentages in outer regions), and (4) in most cases a gradual increase in coverage (growth size) of species of lichens as one moved away from the center of the city.

Additional studies by LeBlanc (1969) involved exposing lichen thalli to various sulfur dioxide concentrations under laboratory conditions. A concentration of 5 ppm was used in these experiments and the exposure time under varying moisture conditions was one hour. The results obtained led LeBlanc to the following conclusions: (1) abnormalities appear, such as bleaching of the chlorophyll, permanent plasmolysis of the cells, and sporadic brown spots on the chloroplasts, in specimens exposed to sulfur dioxide at high humidities; (2) sulfurous acid, an efficient bleaching agent, was present in the thallus and could account for the loss of color by the thallus; (3) sulfate (SO_4^{--}) ions were present in the thallus and might be responsible for higher osmotic concentrations outside the algal cells and thus cause plasmolysis; (4) sulfate concentration in the thallus is directly related to the relative humidity prevalent at the time of exposure to sulfur dioxide (the higher humidities had higher absorption rates); and (5) the presence of Mg^{++} ions in the thallus extract and brown spots on the chloroplasts suggest that Mg^{++} has been removed from chlorophyll a converting it to phaeophytin a. This last conclusion was confirmed by noting the similarity of the absorption spectrum of chlorophyll a, extracted from the sulfur dioxide exposed thalli, to that of phaeophytin a. The data mentioned above clearly show a possible mechanism for the damage sulfur dioxide causes to epiphytes. Direct experimental proof that this occurs in nature is still lacking. This evidence obtained, however, has convinced LeBlanc and many other workers.

LeBlanc and DeSloover (1970) extended the Montreal studies and have proposed the use of the distribution of epiphytes in the calculation of an Index of Atmospheric Purity (I.A.P.). Such an index would provide a number value that could be used as an indication of the richness of the epiphytic vegetation at any specific site. LeBlanc and DeSloover suggest that the value obtained from their I.A.P. method could be used to map any city in order to determine the degree of atmospheric pollution in different areas of the city. Indeed they have provided a complex system of maps and overlays of Montreal to indicate the efficiency of their I.A.P. method.

LeBlanc (1971) has compared computerized maps of the Montreal area in his review of the various methods of mapping cities by using epiphytic distributions. He reports that maps showing sites of heavy industrialization and residential locales correspond almost exactly with maps showing zones lacking in epiphytes. LeBlanc concedes that these maps do not prove that pollutants caused the epiphytes to disappear nor does he think that they should replace Continuous Air Monitoring Program stations; however, he does feel that they further confirm his contention that epiphytes are good indicators of atmospheric pollution or purity.

Barkman (1958) reviewed the literature, up to that time, on both sides of the controversy and concluded that a combination of city induced drought and atmospheric contaminants had a clear effect on the distribution of lichens in urban areas. He further suggested that the city induced drought affects the distribution over a much shorter distance and operates directly, whereas atmospheric contaminants were considered to have an indirect effect and affect the distribution over a much greater range.

Barkman (1968) conducted further research on the effects of atmospheric pollutants on lichens and concluded that pollutants represent the major factor producing lichen deserts in cities. He reported that (1) the Dutch flora has lost 27% of its lichen species in the last one hundred years and that many of the species lost were xerophytic, (2) lichens have deteriorated in areas where there was no significant change in environmental conditions, (3) the absence of certain species in humid forests where the rain has a high sulfate concentration, and (4) that lichen deserts extend far beyond the microclimate of the city. In addition, Barkman presented evidence that appears to refute the theory held by many lichenologists that the usual pattern of lichen disappearance is fruticose forms first, then foliose, and finally crustose forms (Brodo, 1966). He states that of 107 species that have become extinct or rare in Sweden, 86 of them were crustose forms. He believes that since crustose lichens are so closely associated with their substratum, changes in the pH of the substratum, caused by rainfall containing sulfates, can and do cause the demise of crustose lichens.

Recently my attention was called to an abstract of a paper by LeBlanc and Rao (1971). In this report they indicated that results from transplant studies using 15 species of epiphytic lichens and mosses, in the vicinity of an aluminum factory, indicate fluoride effluence from the factory causes (1) imbalances with respect to water relations and light absorption, and (2) significant changes in the fluoride concentrations in the lichen thallus and moss gametophyte. LeBlanc and Rao suggest that these changes cause harmful effects to the life processes of these plants.

The data on what the lethal doses of sulfur dioxide and other contaminants are for epiphytes is not yet clear in the literature and comment on them is reserved until adequate experimental proof will enable firm conclusions to be drawn.

Brodo (1966) has provided the only study of the effects of air pollution on lichen distribution and speciation in the United States, specifically the New York-Long Island area. In his investigation of the city's effects, Brodo (1966) used three approaches: (1) a transect study of lichens in red oak stands along the north shore at varying distances from the city, (2) the partial reconstruction of past distribution of some common lichens for comparison with their present distribution, and (3) transplant experiments with corticolous lichens.

Brodo established a transect line in a "generally" east-west direction from central New York City to "relatively" undisturbed central Long Island and investigated 12 red oak stands along the transect. In each stand 50 trees were selected, in an unbiased manner, and the lichen samples were taken from each tree at the base and at breast height. From his transect study, Brodo made the following observations: (1) a definite trend exists in lichen distribution in the area studied with frequencies increasing more or less continuously up to 45 miles from Brooklyn before becoming erratic, (2) different species appear in the flora at different distances from the city, and (3) most species appear on the transect at approximately 25 miles from the center of Brooklyn.

By comparing the present distributions of 14 common species with their previous distributions, (no mention is given of the age of the data representing the previous distribution), Brodo (1966) found that most lichens at that time had their distribution limits approximately 25 miles from the city. The limiting factor clearly appeared to be related to the city's influence. He further reported that at one time the lichen flora of Brooklyn and Queens was similar to that of the north shore of Long Island today.

Brodo's transplant experiments involved the use of a foliose lichen (*Parmelia caperata*) and two crustose lichens (*Lecanora caesiorubella* and *Graphis scripta*). Due to the damage from bark-exudation to the crustose forms, only the data from the studies on *P. caperata* were reported. Twenty-five bark discs were removed from trees where the lichen population showed no effects of the city. Twenty discs were transplanted on other trees in four new locations (5 discs per location) at various distances from the city. Five discs were returned to their original position to act as controls. In each of the transplants care was taken to place each one in the very same position on the new tree as it was on the original one. Examination of the transplants after four months showed damage to the thalli of those closest to the city. After one year the thallus of most lichens except the controls were shown to be damaged. Notably, the *P. caperata* transplants conformed closely with their normal distribution limits.

CHAPTER III

MATERIALS AND METHODS

In an attempt to collect a representative sample of lichens in urban Atlanta and provide some indication of their distribution, during the spring and early summer of 1971 four transect lines were established in the eastern half of metropolitan Atlanta. Using a Gulf Oil map of the city, transect lines were extended from the State Capitol Building (designated as the city's center) to the "Perimeter highway", Interstate 285. Corresponding transect lines were established by my fellow student, Miss Doris Fritchman, who studied the western half of the city. My transects were designated A, B. C, and D, in a clockwise fashion, with their approximate compass directions being (A) north-northeast, (B) east-northeast, (C) east-southeast, and (D) south-southeast. Each transect was then divided into one mile intervals. This resulted in transect (A) having 12 intervals, transect (B) 9, transect (C) 8, and transect (D) 6. (See Appendix) Numbers were then assigned to each interval to indicate potential collection sites. The 35 potential sites were then numbered with numbers 1 through 12 on transect A, 13 through 21 on transect B, 22 through 29 on transect C, and 30 through 35 on transect D. Lateral collection limits for each transect are designated on the map by the space covered on the transect by a Carter's Hi-Liter felt marker and represents an area approximately 100 meters wide.

Trees representing the genera Quercus and Ulmus were selected as the source of lichen samples for the study. Q. nigra, Q. falcata, and Q. alba were the principal oak species used. U. alata and U. americana were the species of elm sampled. The reasons for their selection were due to (1) their similarities in bark features (LeBlanc, 1969), (2) their general abundance in the urban Atlanta area, and (3) the large lichen population these trees supported. Only isolated street side trees were sampled in this study because it has been suggested that lichens growing on widely dispersed trees are better subjected to the full influence of the ambient air (LeBlanc, 1969; Barkman, 1969) (Fig. 1-2). Forested areas such as those found in parks and undeveloped areas were avoided due to the possible filtering effect of their combined canopy. The presence of these forested or undeveloped areas, and in some cases the lack of any trees within a collection interval, resulted in 10 of the 35 potential collecting sites not being sampled.

Specific collection sites were established by driving through the streets in each of the transects' intervals until a suitable location was found. Suitable locations were those that contained 4 to 6 trees (only one site contained just 4 trees) of either oak or elm species, or combinations of the two, and that were situated near the street

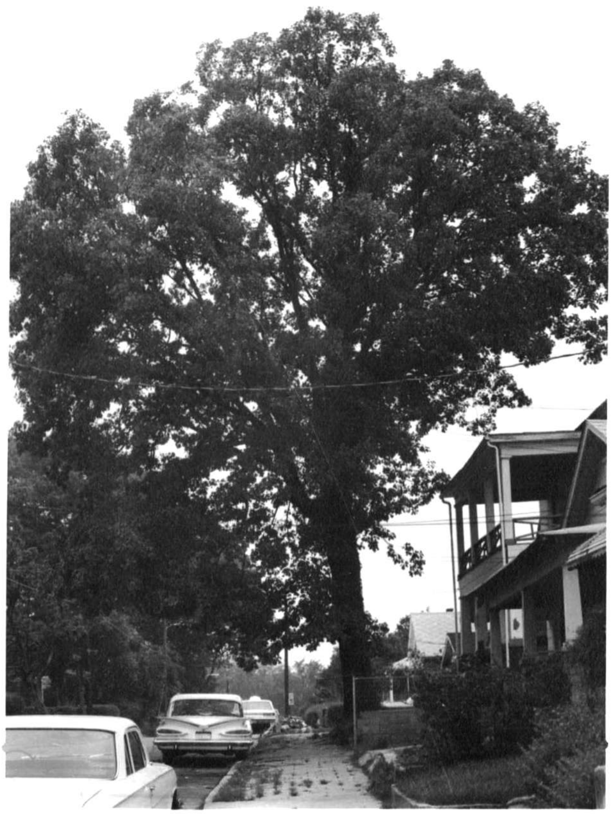


Fig. 1. Single specimen of Quercus falcata along street illustrating typical appearance and setting of trees sampled at various sites along transect lines.

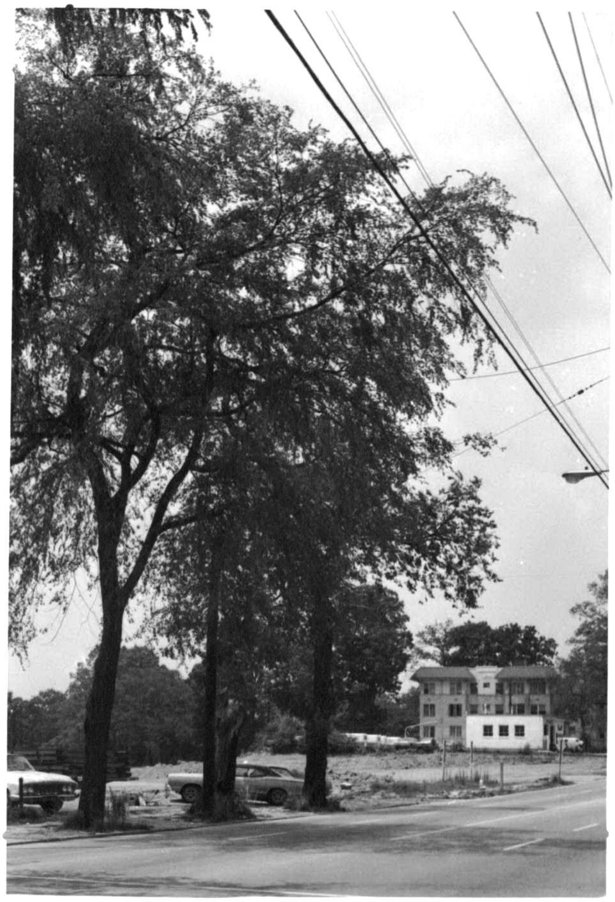


Fig. 2. Ulmus alata trees along street illustrating typical appearance and setting of trees sampled at various sites along transect lines.

or in the yard of a nearby residence. Lichens that I could not readily identify were removed from the tree with a sharp hunting knife, placed in an envelope, labeled as to site number and tree species, and returned to the laboratory for identification. Lichens were examined in a zone from the base to a height of 6 feet on the trunk of trees sampled. Specimen were randomly taken from any side of the tree.

Non-crustaceous (foliose and fruticose forms) were identified to genera and species with the aid of a taxonomic key by Hale (1969). Crustaceous forms proved to be more difficult to identify and were keyed only to genus. Failure to identify crustose forms below the rank of genus was due to the lack of keys that describe crustose species and the fact that this group of lichens is exceedingly difficult to classify. Crustose lichens have long been neglected by lichenologists.

All specimen collected will be assigned an Atlanta University Collection Number and deposited in the Mycological Collection of the Atlanta University Herbarium.

CHAPTER IV

EXPERIMENTAL RESULTS

Two factors, (1) the absence of either *Quercus* or *Ulmus* trees, and (2) the presence of these trees in forested areas resulted in 10 (28.5%)of the thirty-five potential collection sites not being suitable for this study. The sites excluded were numbered 1, 10, 11, 13, 15, 16, 21, 29, 30, and 35 (Table 1-4, also see Appendix for the specific location of these sites). The number of trees examined at each of the 25 remaining sites varied from 4 to 6 trees (4 occurred at only one site, Table 1-4). Samples were taken from 135 trees; 47 (42.2%) of which were species of *Ulmus* and 88 (57.8%) were species of *Quercus* (Table 5).

Evidence of lichen death was noted at 15 (60%) of the 25 collection sites (Table 5). Visual observation at the site was the basis for determining where death had occurred. Lichen death is evident by the presence of a pinkish or black discoloration of portions of newer parts of the thallus along with fragmentary remains of older thalli.

Thallus sterility was a feature noted for most lichens collected. Whether or not a specific lichen thallus was sterile was determined by microscopic examination in the laboratory. Thalli that lacked ascocarps, i.e., perithecia

Table 1. Summary of data from lichen collections along Transect A.

	Site Number											
	1	2	3	4	5	6	7	8	9	10	11	12
Distance from city center (miles)	1	2	3	4	5	6	7	8	9	10	11	12
# *Quercus* species at site	0	3	5	0	3	4	4	4	5	0	0	3
# *Ulmus* species at site	0	2	1	5	2	1	2	1	0	0	0	1
Total trees sampled	0	5	6	5	5	5	6	5	5	0	0	4
Lichen species collected:												
Non-crustaceous	0	1	8	8	6	7	9	12	5	0	0	2
Crustaceous	0	2	2	2	3	3	3	5	6	0	0	2
Total	0	3	10	10	9	10	12	17	11	0	0	4
# Sterile thalli	0	3	9	8	9	10	10	15	10	0	0	4
Evidence of thallus death at site	0	+	+	+	+	+	-	-	-	0	0	-

(+) indicates evidence of death (-) means no death was observed

Table 2. Summary of data from lichen collections along Transect B.

	Site Number								
	13	14	15	16	17	18	19	20	21
Distance from city center (miles)	1	2	3	4	5	6	7	8	9
# *Quercus* species at site	0	4	2	0	0	0	0	0	0
# *Ulmus* species at site	0	2	4	0	0	5	5	5	0
Total trees sampled	0	6	6	0	0	5	5	5	0
Lichen Species Collected:									
Non-crustaceous	0	7	6	0	0	7	11	6	0
Crustaceous	0	2	2	0	0	2	3	1	0
Total	0	9	8	0	0	9	14	7	0
#Sterile thalli	0	7	7	0	0	7	10	4	0
Evidence of thallus death at site	0	+	+	0	0	+	-	+	0

(+) indicates evidence of death at site

(-) means no death was observed

Table 3. Summary of data from lichen collections along Transect C.

	Site Number							
	22	23	24	25	26	27	28	29
Distance from city center (miles)	1	2	3	4	5	6	7	8
# *Quercus* species at site	1	0	5	6	6	6	6	0
# *Ulmus* species at site	4	6	0	0	0	0	0	0
Total trees sampled	5	6	5	6	6	6	6	0
Lichen Species Collected:								
Non-crustaceous	1	8	7	7	7	8	11	0
Crustaceous	2	3	2	2	3	3	3	0
Total	3	11	9	9	10	11	14	0
# Sterile thalli	3	11	8	9	9	10	12	0
Evidence of thallus death at site	+	+	+	+	-	-	-	0

(+) indicates evidence of death at site

(-) means no death was observed

Table 4. Summary of data from lichen collections along Transect D.

	Site Number					
	30	31	32	33	34	35
Distance from city center (miles)	1	2	3	4	5	6
# *Quercus* species at site	0	5	5	6	5	0
# *Ulmus* species at site	0	0	0	0	1	0
Total trees sampled	0	5	5	6	6	0
Lichen Species Collected:						
Non-crustaceous	0	4	7	8	8	0
Crustaceous	0	2	2	3	4	0
Total	0	6	9	11	12	0
# Sterile thalli	0	6	7	10	11	0
Evidence of thallus death at site	0	+	+	-	-	0

(+) indicates evidence of death at site

(-) means no death was observed

Table 5. Summary of lichen collection data from all Transects.

	Transect A	B	C	D	Totals
# Collection sites	9	5	7	4	25
# Sites with evidence of thallus death	5	4	4	2	15
Trees sampled:					
Oak trees	31	6	30	21	88
Elm trees	15	21	10	1	47
Total	46	27	40	22	135
#Lichen thalli collected	86	47	67	38	238
#Lichen thalli sterile	78	35	62	34	209

or apothecia, were recorded as being sterile. Of 238 lichen thalli examined in this study, 209 (87.8%) lacked ascocarps (Table 5). All of the thalli observed are not included in the above figure, however, because at each given site duplicate samples of the same species might have been collected, yet a reference to only a single sample for each species determined was recorded.

Laboratory examination of lichen thalli collected resulted in the identification of 42 species of lichens (Table 6-7, also see Check-List). The collected lichens were first divided into crustaceous or non-crustaceous, i.e., foliose and fruticose, forms. Only 8 (19%) of the species collected were crustaceous. These crustaceous forms represented 6 genera (Table 6). Of the 34 non-crustaceous species reported, only one, Cladonia apodocarpa, was fruticose. The remaining 33 species were foliose and represented 9 genera.

With respect to tree species distribution 16 (38%) of the 42 species were found on both Quercus and Ulmus, 24 (57%) were found only on Quercus, and 2 (5.8%) were found only on Ulmus (Table 8). Figure 3 shows the transects used by Miss D. Fritchman in her companion study of the lichens found in western metropolitan Atlanta.

Lichen distribution patterns (Fig. 4-25) revealed that 25 (59%) of the species first occurred at a distance

Table 6. Distribution of non-crustaceous lichen species in Eastern Metropolitan Atlanta

Non-crustaceous Lichens	Genera of Tree Q	U	Distance Lichen First Occurred From the City Center (miles) 1	2	3	4	5	6	7	8	9	10	11	12	# Sites each species Occurred
<u>Anaptychia</u>															
<u>obscurata</u>	+								X	–	–	–	–	–	1
<u>ravenelii</u>	+	+		X	–	–	–	–	–	–	–	–	–	–	3
<u>speciosa</u>	+	+							X	–	–	–	–	–	2
<u>squanulosa</u>	+						X	–	–	–	–	–	–	–	1
<u>Candelaria</u>															
<u>concolor</u>	+	+	X	–	–	–	–	–	–	–	–	–	–	–	22
<u>Cetaria</u>															
<u>oakesiana</u>	+			X	–	–	–	–	–	–	–	–	–	–	1
<u>pinastri</u>	+					X	–	–	–	–	–	–	–	–	1
<u>Cladonia</u>															
<u>apodocarpa</u>	+					X	–	–	–	–	–	–	–	–	5
<u>Parmelia</u>															
<u>aurulenta</u>		+			X	–	–	–	–	–	–	–	–	–	2

Table 6. (Continued)

Non-crustaceous Lichens	Genera of Tree Q	U	Distance Lichen First Occurred From the City Center (miles) 1	2	3	4	5	6	7	8	9	10	11	12	# Sites each species occurred
Parmelia															
caperata	+	+		X	-	-	-	-	-	-	-	-	-	-	22
caroliniana	+	+		X	-	-	-	-	-	-	-	-	-	-	6
ceterata	=			X	-	-	-	-	-	-	-	-	-	-	11
confoederata	+									X	-	-	-	-	1
crinita	+						X	-	-	-	-	-	-	-	2
dilatata	+					X	-	-	-	-	-	-	-	-	1
dissecta	+							X	-	-	-	-	-	-	1
galbina	+								X	-	-	-	-	-	1
mellissii	+							X	-	-	-	-	-	-	1
michauxiana	+	+		X	-	-	-	-	-	-	-	-	-	-	7
reticulata	+	+				X	-	-	-	-	-	-	-	-	6
rudecta	=	+		X	-	-	-	-	-	-	-	-	-	-	22
scortella	+								X	-	-	-	-	-	1

Table 6. (Continued)

Non-crustaceous Lichens	Genera of Tree Q	U	Distance Lichen First Occurred From the City Center (miles) 1	2	3	4	5	6	7	8	9	10	11	12	# Sites each species occurred
<u>Parmelia</u>															
<u>subtinctoria</u>	+								X=	-	-	-	-	-	2
<u>texana</u>	+						X	-	-	-	-	-	-	-	1
<u>tinctorum</u>	+							X	-	-	-	-	-	-	2
<u>Parmeliopsis</u>															
<u>hyperopta</u>	+						X	-	-	-	-	-	-	-	1
<u>Platismata</u>															
<u>glauca</u>	+	+		X	-	-	-	-	-	-	-	-	-	-	4
<u>Physcia</u>															
<u>lacinulata</u>	+				X	-	-	-	-	-	-	-	-	-	2
<u>millegrana</u>	+	+		X	-	-	-	-	-	-	-	-	-	-	10
<u>tribacoides</u>	+	+				X	-	-	-	-	-	-	-	-	6
<u>Pyxine</u>															
<u>caesiopruinosa</u>	+	+			X	-	-	-	-	-	-	-	-	-	5

Table 6. (Continued)

Non-crustaceous Lichens	Genera of Trees Q	U	1	2	3	4	5	6	7	8	9	10	11	12	# Sites each species occurred
			Distance Lichen First Occurred From the City Center (miles)												
<u>Pyxine</u>															
<u>sorediata</u>	+			X	-	-	-	-	-	-	-	-	-	-	5
<u>Lobaria</u>															
<u>erosa</u>	+	+					X	-	-	-	-	-	-	-	6
<u>pulmonaria</u>		+		X	-	-	-	-	-	-	-	-	-	-	1

Legend: X = first occurrence of the Lichen

- = lichen has occurred in an earlier zone

+ = lichen occurred on that tree species

Q = <u>Quercus</u>

U = <u>Ulmus</u>

Table 7. Distribution of crustaceous lichen species in Eastern Metropolitan Atlanta

Crustaceous Genera	Genera of Tree Q	U	Distance Lichen First Occurred From the City Center (miles) 1	2	3	4	5	6	7	8	9	10	11	12	# Sites each species occurred
Buellia sp.	+	+	X	–	–	–	–	–	–	–	–	–	–	–	17
Graphis sp.	+						X	–	–	–	–	–	–	–	8
Lecanora															
Collection A					X	–	–	–	–	–	–	–	–	–	6
Collection B	+	+		X	–	–	–	–	–	–	–	–	–	–	8
Collection C	+						X	–	–	–	–	–	–	–	2
Lecidia sp.	+	+	X	–	–	–	–	–	–	–	–	–	–	–	18
Rinodina sp.	+					X	–	–	–	–	–	–	–	–	4
Trypethelium sp.	+						X	–	–	–	–	–	–	–	3

Legend: X = first occurrence of the Lichen — = lichen has occurred in an earlier zone

+ = lichen occurred on that tree species

Q = _Quercus_ U = _Ulmus_

Table 8. Summary of data on lichen distribution in Eastern Metropolitan Atlanta.

	Lichen Collected: Non-Crustaceous	Lichen Collected: Crustaceous	Total	Total # Species Found within a Zone plus those in the previous Zone	%
Tree Genera					
Quercus only	20	4	24		57
Ulmus only	2	0	2		5
Quercus & *Ulmus*	12	4	16		38
Distance from City Center where Species first occurred (miles):					
1	1	2	3	3	7
2	11	1	12	15	35
3	3	1	4	19	45
4	5	1	6	25	59
5	5	3	8	33	78

Table 8. (Continued)

	Lichen Collected				
	Non-Crustaceous	Crustaceous	Total	Total # Species Found within a Zone plus those in the previous Zone	%
Distance from City Center where Species first occurred (miles):					
6	3	0	3	36	88
7	5	0	5	41	97
8	1	0	1	42	100
9	0	0	0	42	100
10	0	0	0	42	100
11	0	0	0	42	100
12	0	0	0	42	100

Fig. 3. Illustrates the transects used in the survey reported here and those of Miss Doris Fritchman's survey (Sites 36-68) in western metropolitan Atlanta. Transects are numbered as to their potential collection sites.

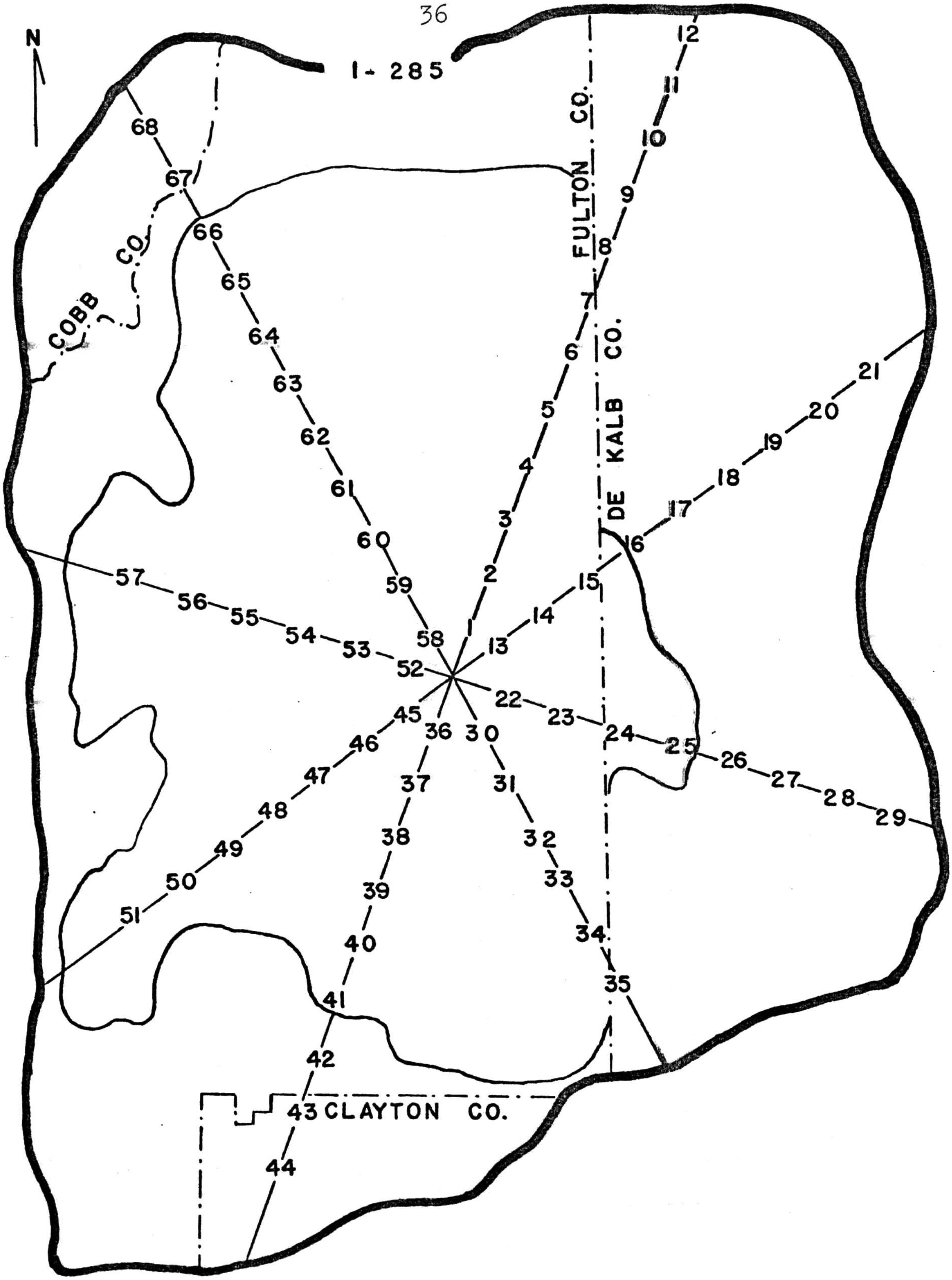

N
I- 285
FULTON CO.
DE KALB CO.
COBB CO.
CLAYTON CO.
1 2 3 4 5 6 7 8 9 10 11 12
13 14 15 16 17 18 19 20 21
22 23 24 25 26 27 28 29
30 31 32 33 34 35
36 37 38 39 40 41 42 43 44
45 46 47 48 49 50 51
52 53 54 55 56 57
58 59 60 61 62 63 64 65 66 67 68

Fig. 4. The distribution of *Anaptychia obscurata* (●) and *A. ravenelii* (o) in eastern metropolitan Atlanta, as revealed by this study.

Legend:

Interstate 285 - "perimeter highway"

Atlanta city limits

County lines

Transects collected by R. A. Neal

Outline of transects collected by D. A. Fritchman

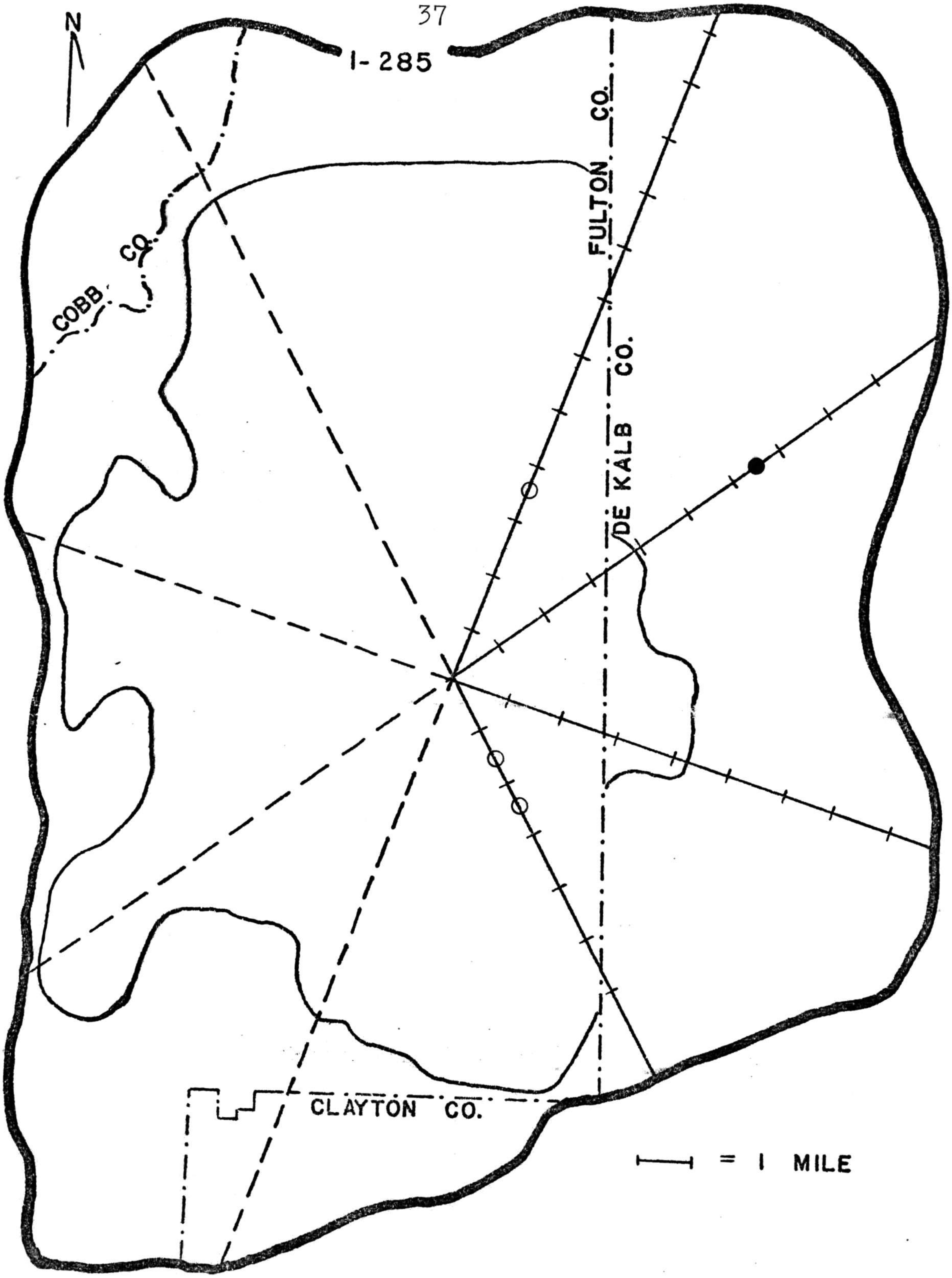

N
I-285
FULTON CO.
COBB CO.
DE KALB CO.
CLAYTON CO.
= I MILE

Fig. 5. The distribution of _Anaptychia speciosa_ (o) and _A. squamulosa_ (●) in eastern metropolitan Atlanta, as revealed by this study.

Legend:

Interstate 285 - "perimeter highway"

Atlanta city limits

County lines

Transects collected by R. A. Neal

Outline of transects collected by D. A. Fritchman

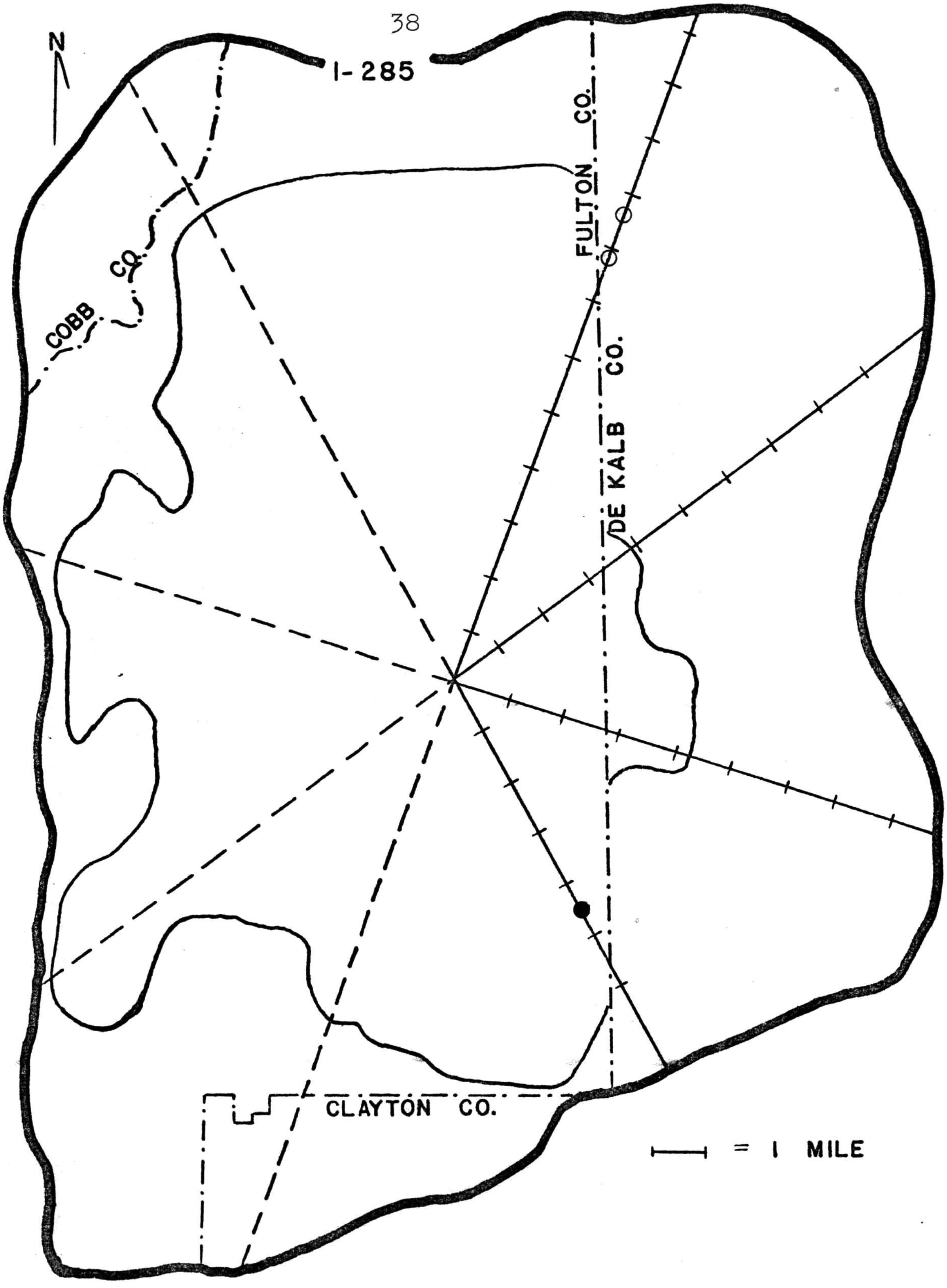

N
I-285
FULTON CO.
COBB CO.
DE KALB CO.
CLAYTON CO.
= 1 MILE

Fig. 6. The distribution of *Candelaria concolor* (o) in eastern metropolitan Atlanta, as revealed by this study.

Legend:

Interstate 285 - "perimeter highway"

Atlanta city limits

County lines

Transects collected by R. A. Neal

Outline of transects collected by D. A. Fritchman

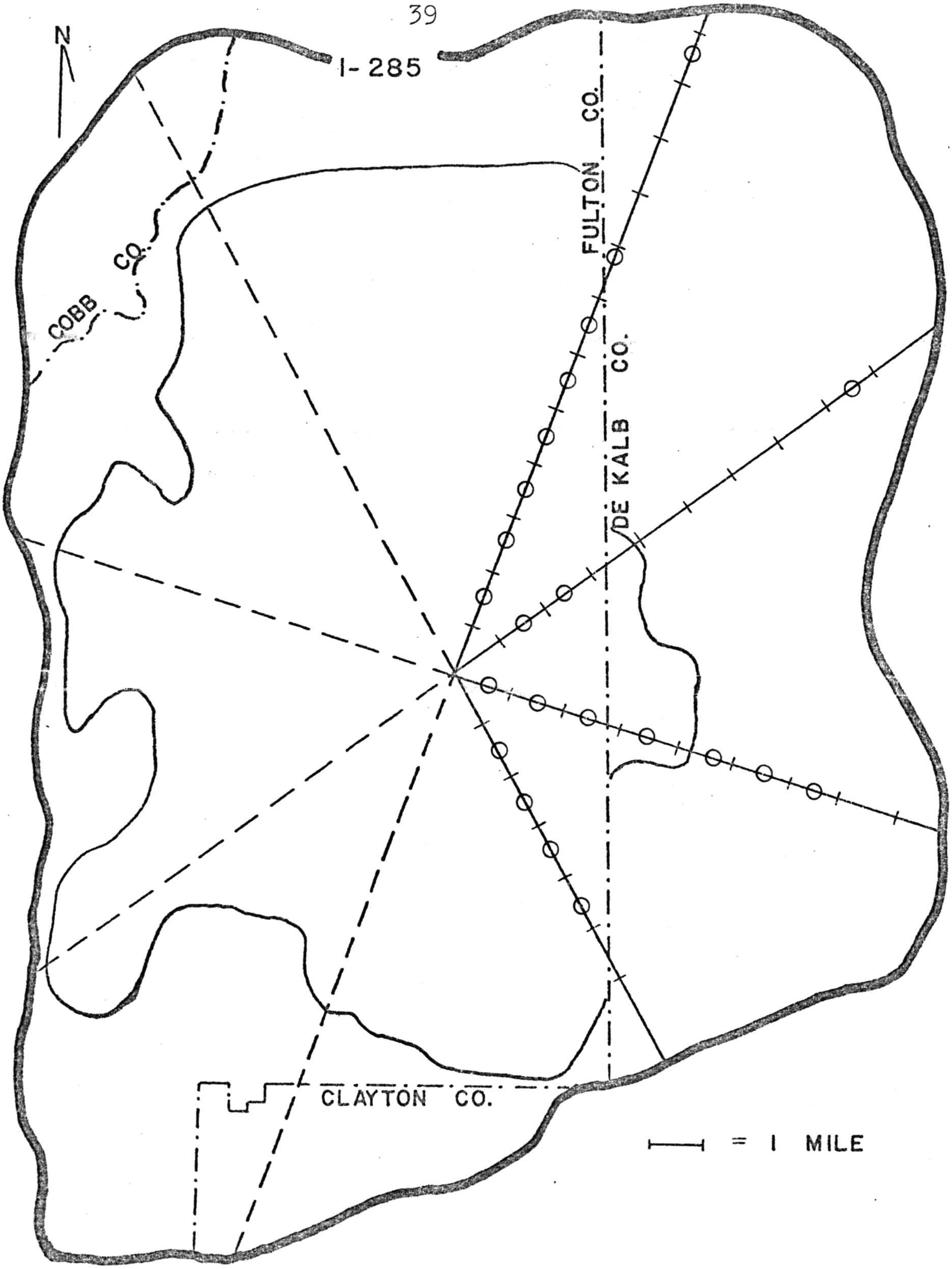

N
I-285
FULTON CO.
DE KALB CO.
COBB CO.
CLAYTON CO.
= I MILE

Fig. 7. The distribution of *Cetaria oakesiana* (●) and *C. pinastri* (o) in eastern metropolitan Atlanta, as revealed by this study.

Legend:

Interstate 285 - "perimeter highway"

Atlanta city limits

County lines

Transects collected by R. A. Neal

Outline of transects collected by D. A. Fritchman

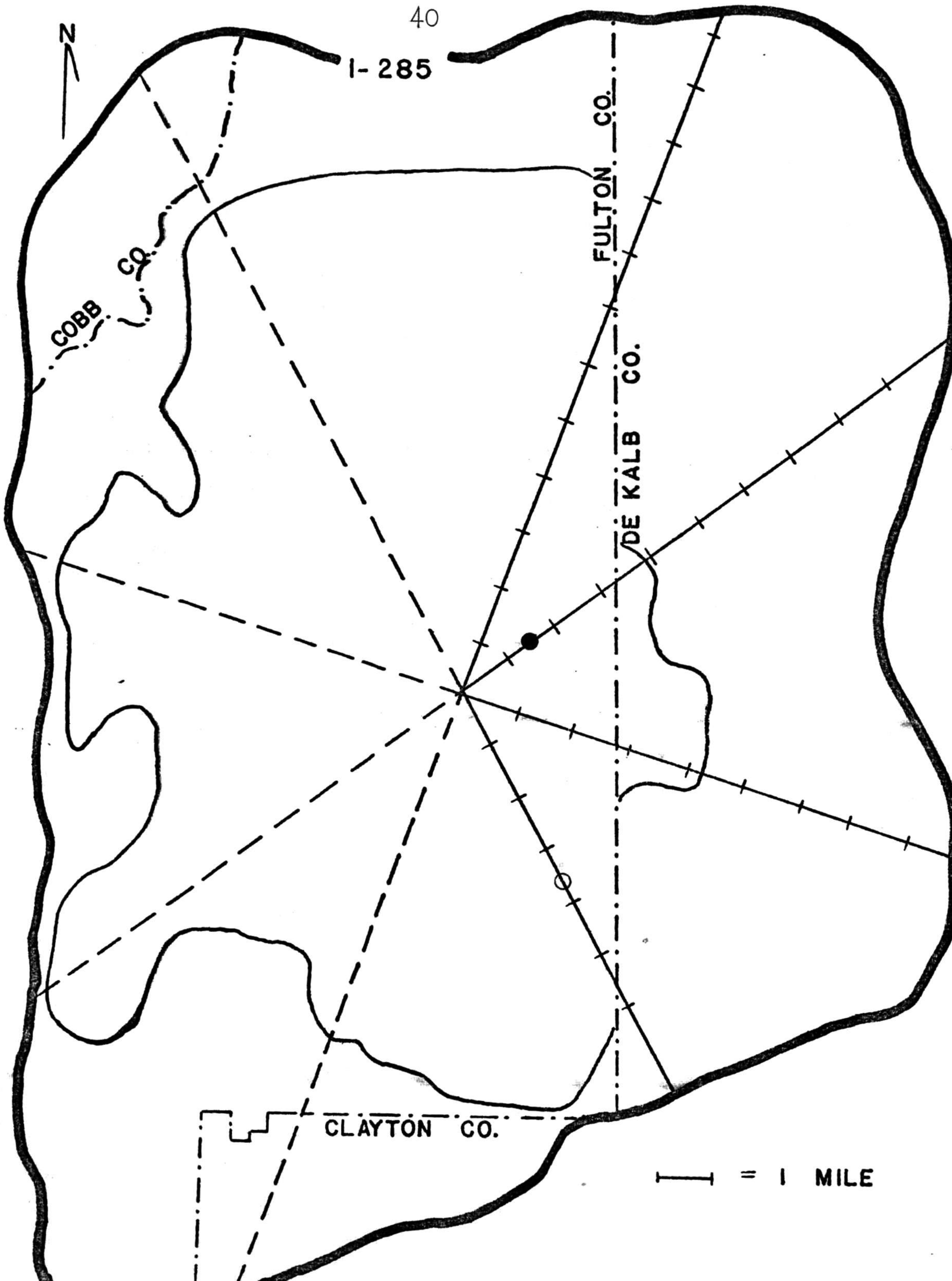

N
I-285
COBB CO.
FULTON CO.
DE KALB CO.
CLAYTON CO.
= I MILE

Fig. 8. The distribution of *Cladonia apodocarpa* (o) in eastern metropolitan Atlanta, as revealed by this study.

Legend:

Interstate 285 - "perimeter highway"

Atlanta city limits

County lines

Transects collected by R. A. Neal

Outline of transects collected by D. A. Fritchman

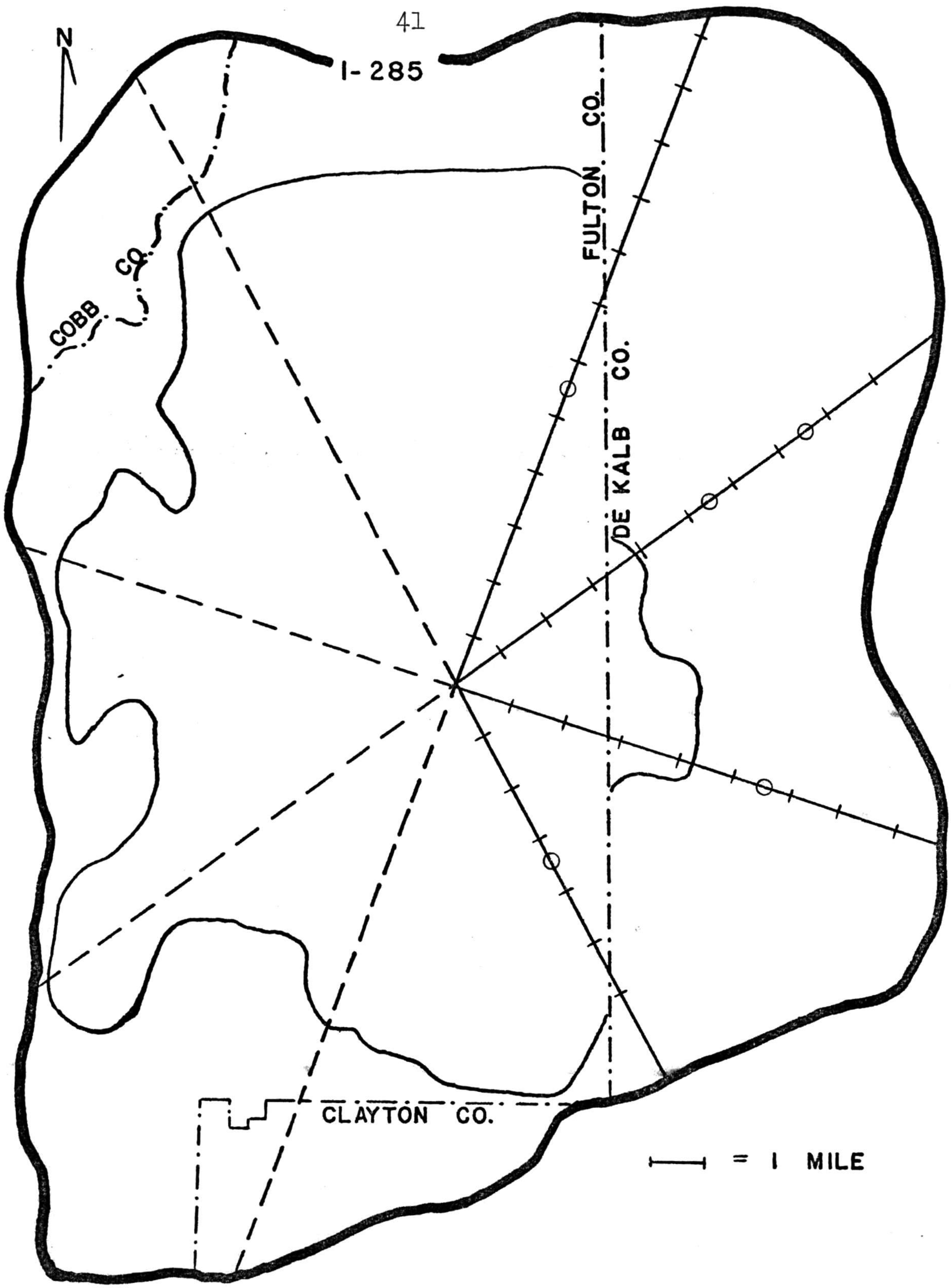

N
I-285
COBB CO.
FULTON CO.
DE KALB CO.
CLAYTON CO.
= I MILE

Fig. 9. The distribution of *Parmelia aurulenta* (●) and *P. caperata* (○) in eastern metropolitan Atlanta, as revealed by this study.

Legend:

Interstate 285 - "perimeter highway"

Atlanta city limits

County lines

Transects collected by R. A. Neal

Outline of transects collected by D. A. Fritchman

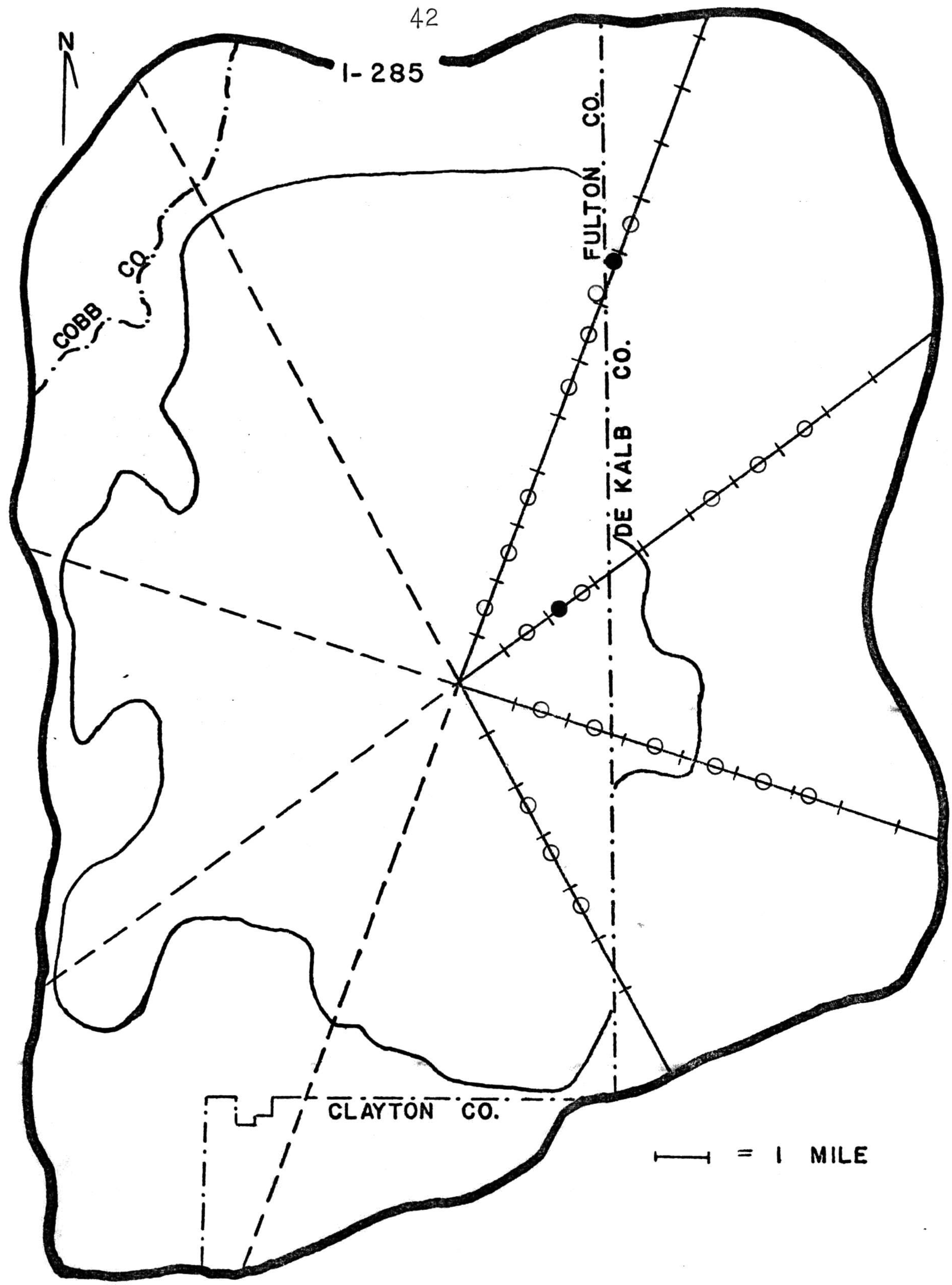

N
I-285
FULTON CO.
DE KALB CO.
COBB CO.
CLAYTON CO.
= I MILE

Fig. 10. The distribution of *Parmelia caroliniana* (●) and *P. ceterata* (o) in eastern metropolitan Atlanta, as revealed by this study.

Legend:

Interstate 285 - "perimeter highway"

Atlanta city limits

County lines

Transects collected by R. A. Neal

Outline of transects collected by D. A. Fritchman

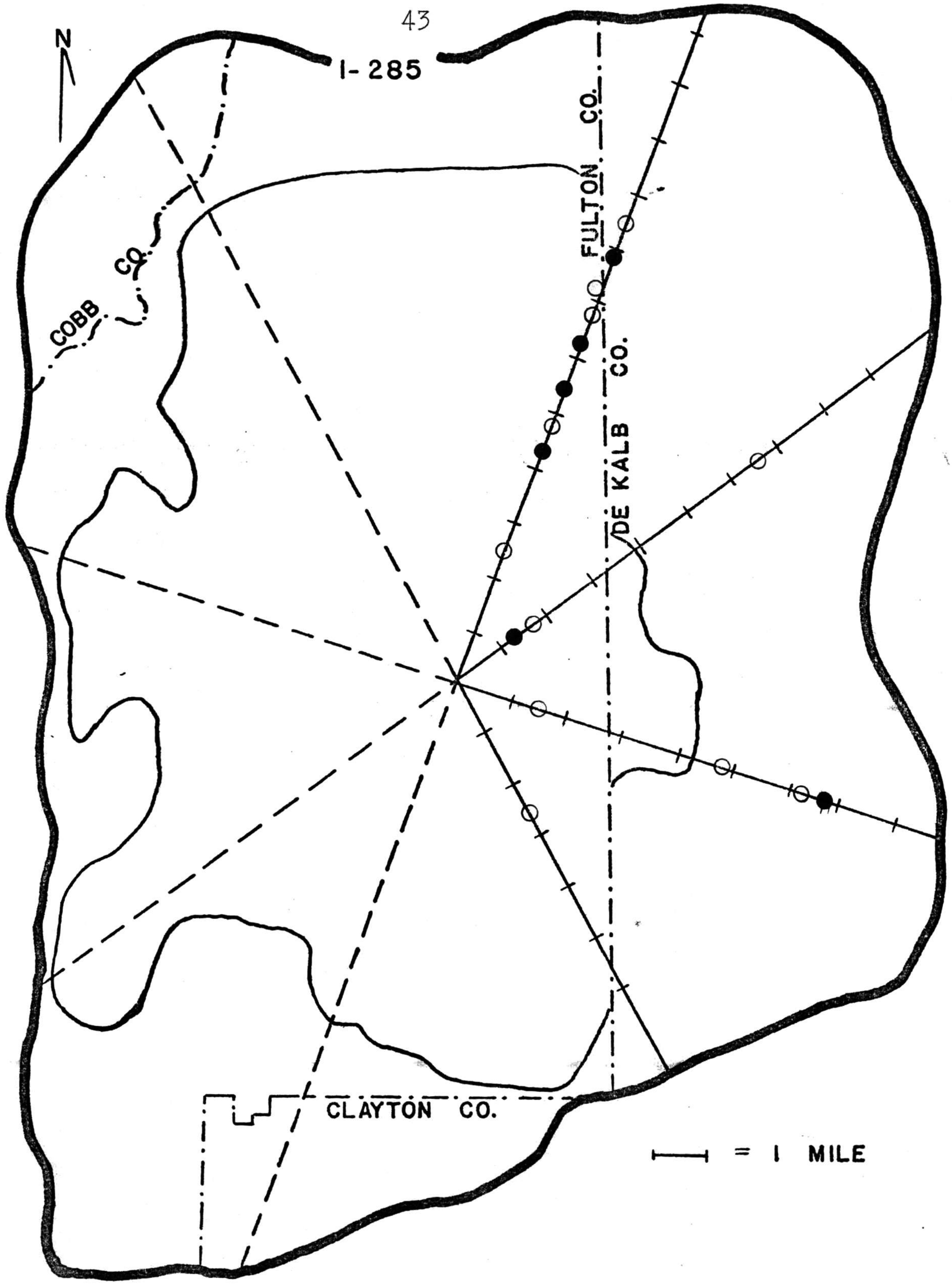

N
I-285
COBB CO.
FULTON CO.
DE KALB CO.
CLAYTON CO.
= I MILE

Fig. 11. The distribution of *Parmelia confoederata* (●) and *P. crinita* (o) in eastern metropolitan Atlanta, as revealed by this study.

Legend:

Interstate 285 - "perimeter highway"

Atlanta city limits

County lines

Transects collected by R. A. Neal

Outline of transects collected by D. A. Fritchman

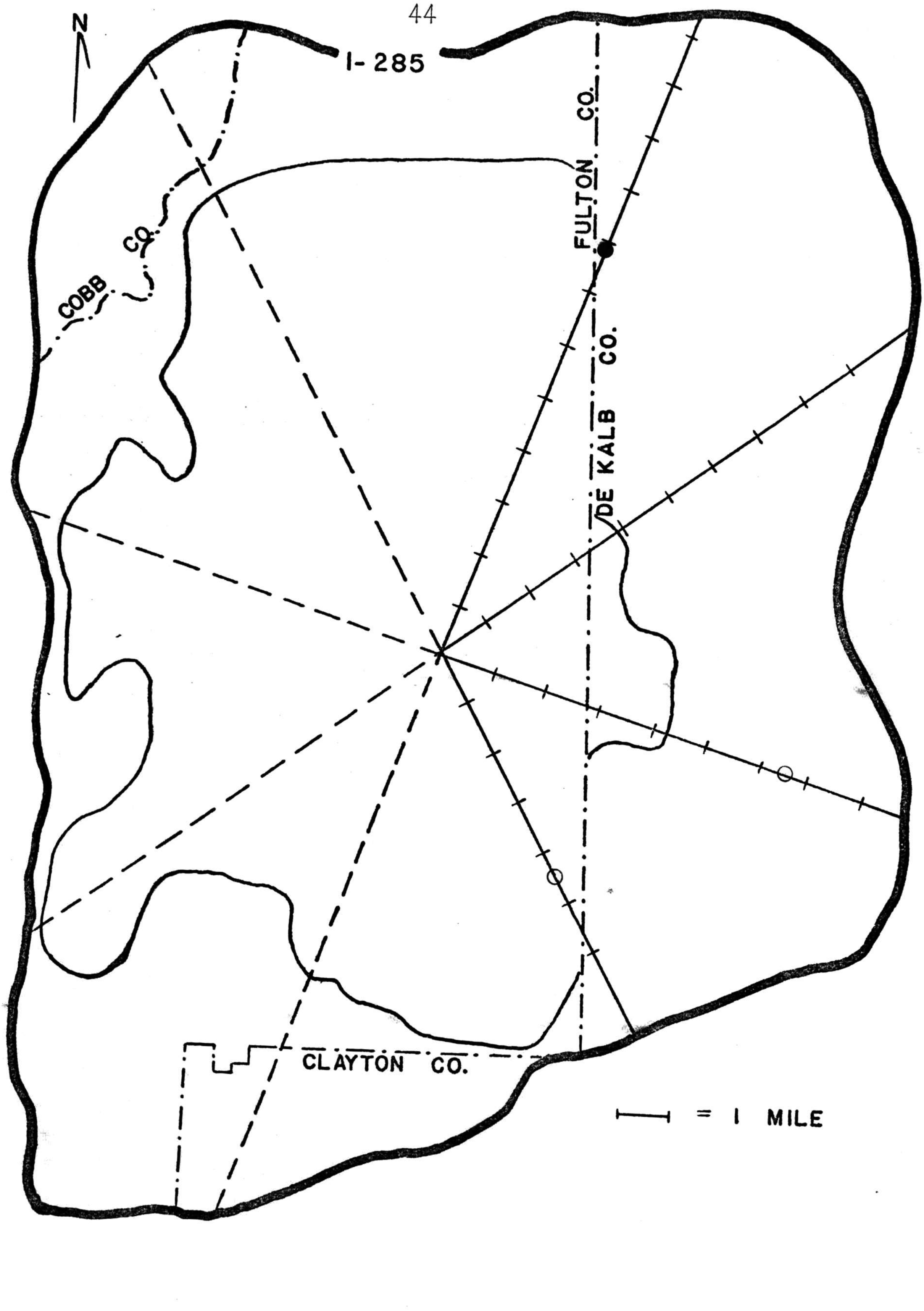

N
I-285
COBB CO.
FULTON CO.
DE KALB CO.
CLAYTON CO.
= I MILE

Fig. 12. The distribution of *Parmelia dilatata* (●) and *P. dissecta* (○) in eastern metropolitan Atlanta, as revealed by this study.

Legend:

Interstate 285 - "perimeter highway"

Atlanta city limits

County lines

Transects collected by R. A. Neal

Outline of transects collected by D. A. Fritchman

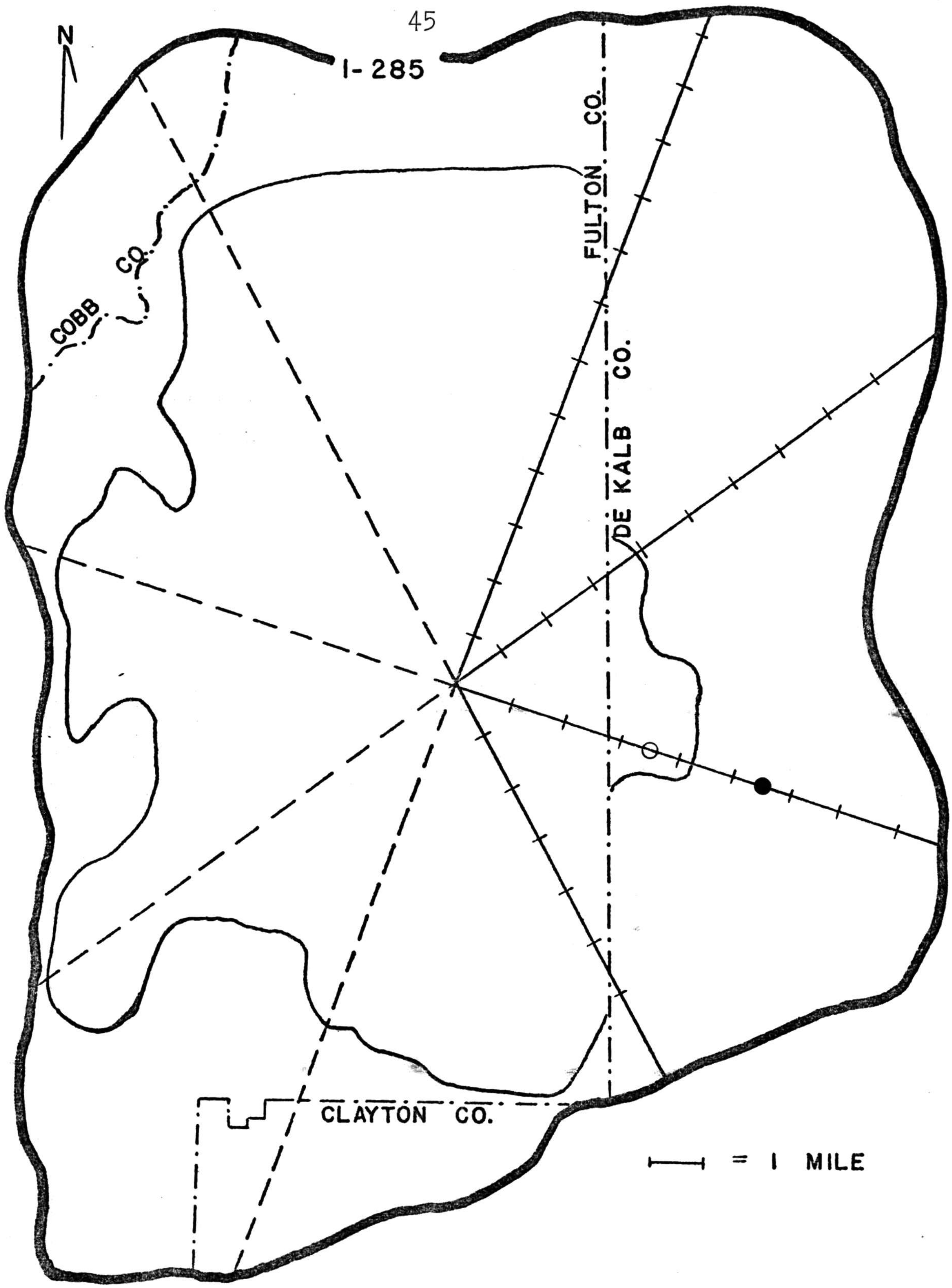

N
I-285
COBB CO.
FULTON CO.
DE KALB CO.
CLAYTON CO.
= 1 MILE

Fig. 13. The distribution of *Parmelia galbina* (○) and *P. mellissii* (●) in eastern metropolitan Atlanta, as revealed by this study.

Legend:

Interstate 285 - "perimeter highway"

Atlanta city limits

County lines

Transects collected by R. A. Neal

Outline of transects collected by D. A. Fritchman

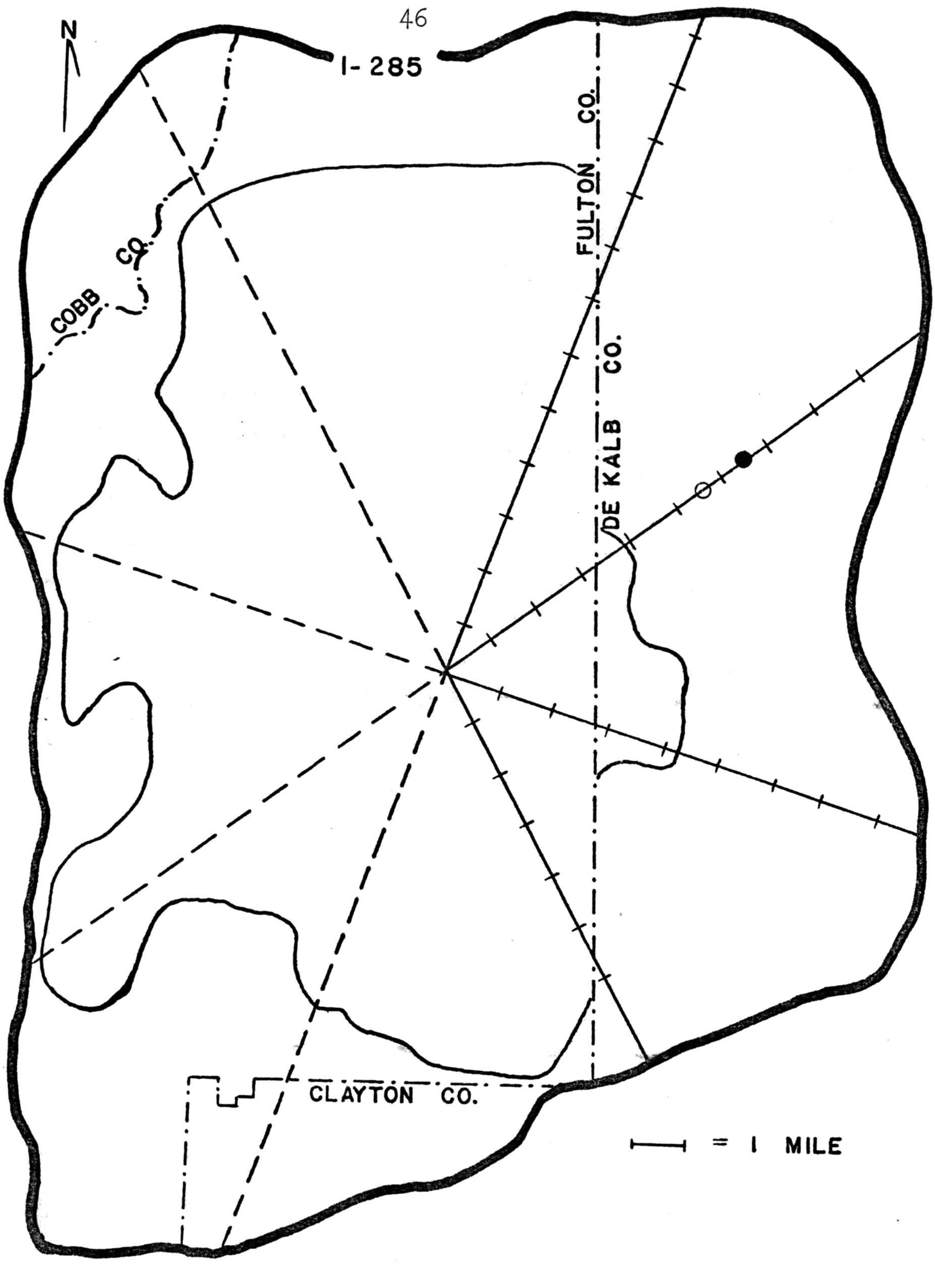

N
I-285
FULTON CO.
COBB CO.
DE KALB CO.
CLAYTON CO.
= I MILE

Fig. 14. The distribution of Parmelia michauxiana (○) and P. reticulata (●) in eastern metropolitan Atlanta, as revealed by this study.

Legend:

Interstate 285 - "perimeter highway"

Atlanta city limits

County lines

Transects collected by R. A. Neal

Outline of transects collected by D. A. Fritchman

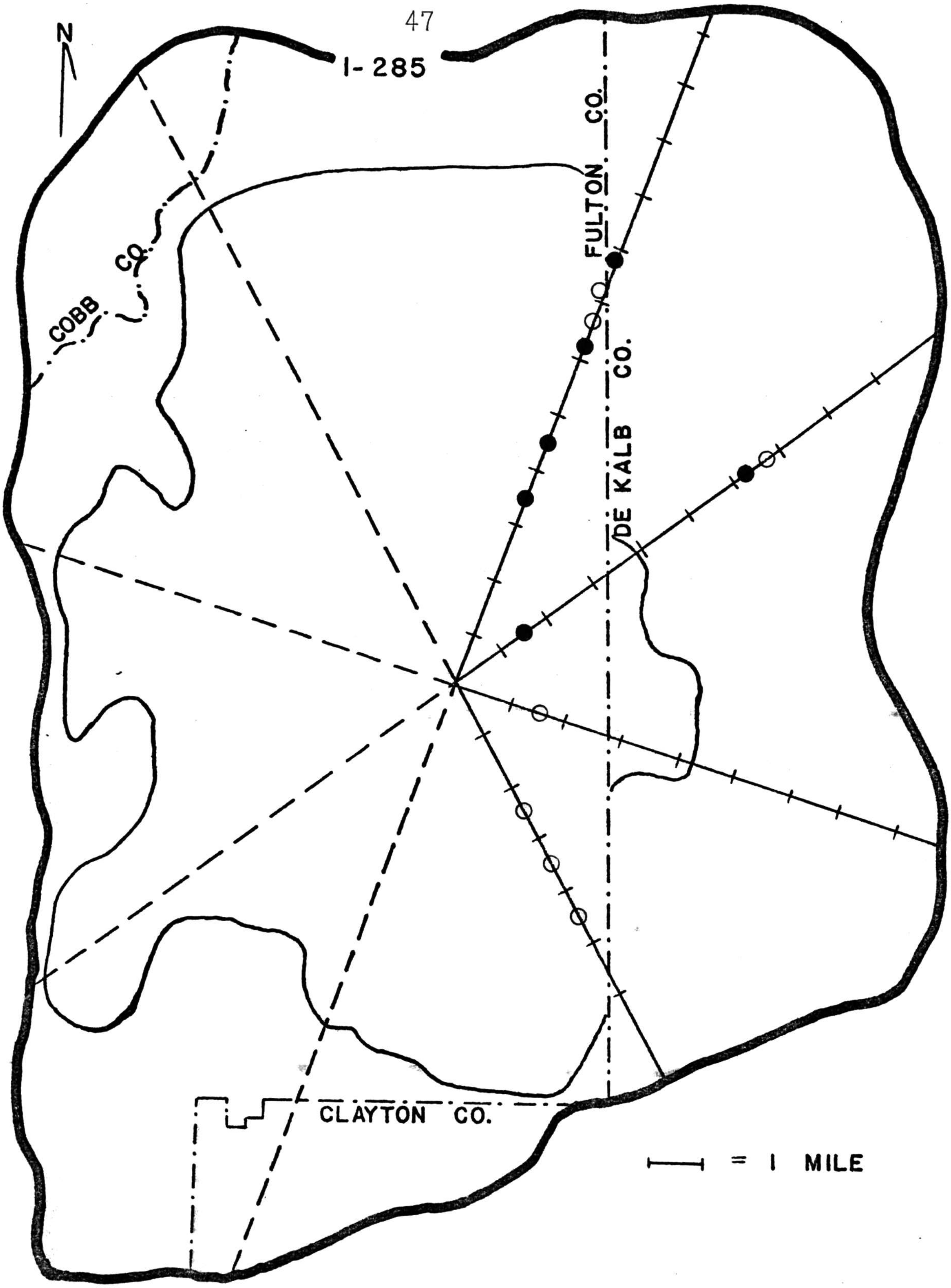

N
I-285
FULTON CO.
COBB CO.
DE KALB CO.
CLAYTON CO.
= 1 MILE

Fig. 15. The distribution of *Parmelia rudecta* (o) and *P. scortella* (●) in eastern metropolitan Atlanta, as revealed by this study.

Legend:

Interstate 285 - "perimeter highway"

Atlanta city limits

County lines

Transects collected by R. A. Neal

Outline of transects collected by D. A. Fritchman

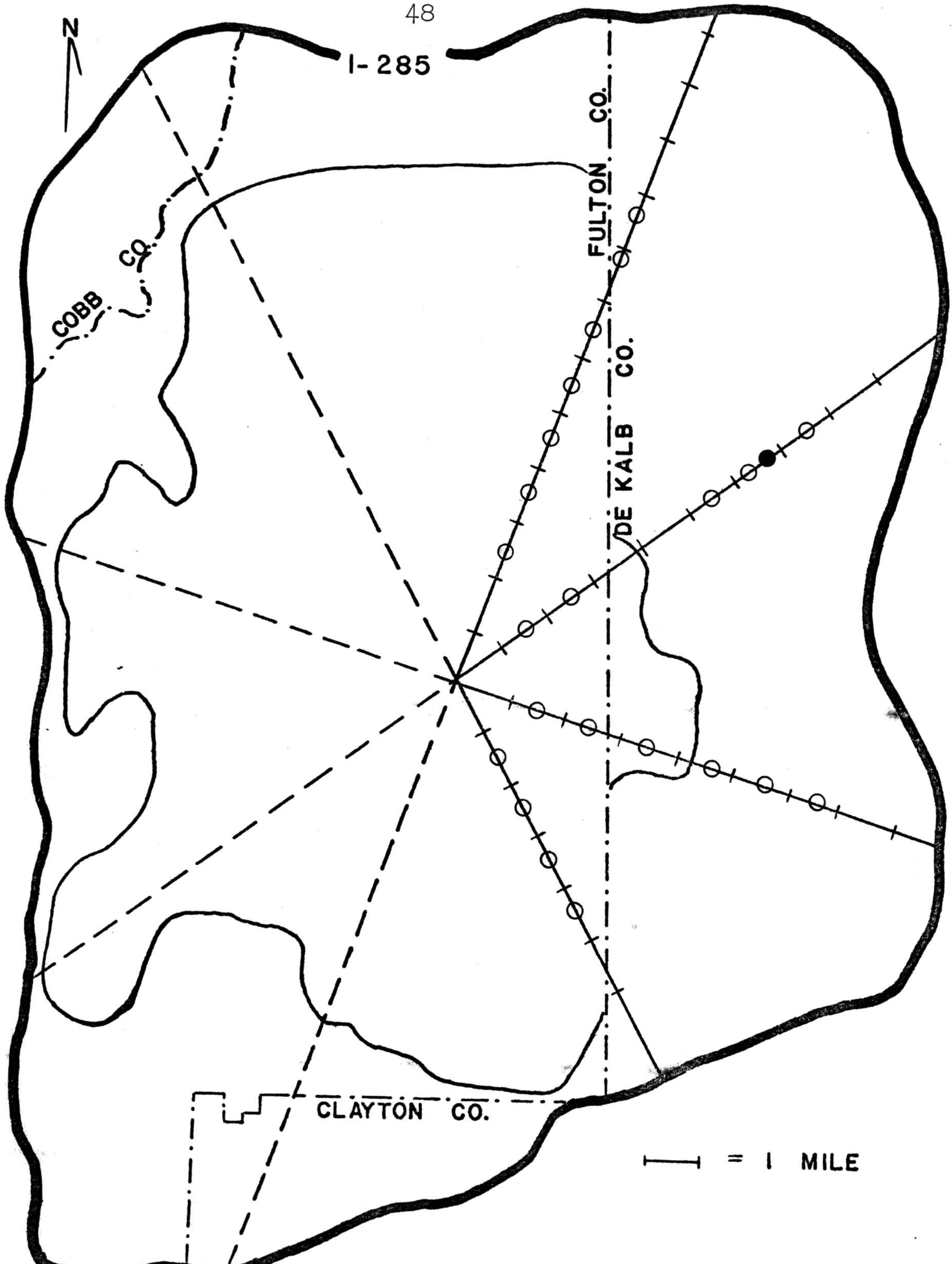

N
I-285
FULTON CO.
DE KALB CO.
COBB CO.
CLAYTON CO.
= 1 MILE

Fig. 16. The distribution of *Parmelia subtinctoria* (o) and *P. texana* (●) in eastern metropolitan Atlanta, as revealed by this study.

Legend:

Interstate 285 - "perimeter highway"

Atlanta city limits

County lines

Transects collected by R. A. Neal

Outline of transects collected by D. A. Fritchman

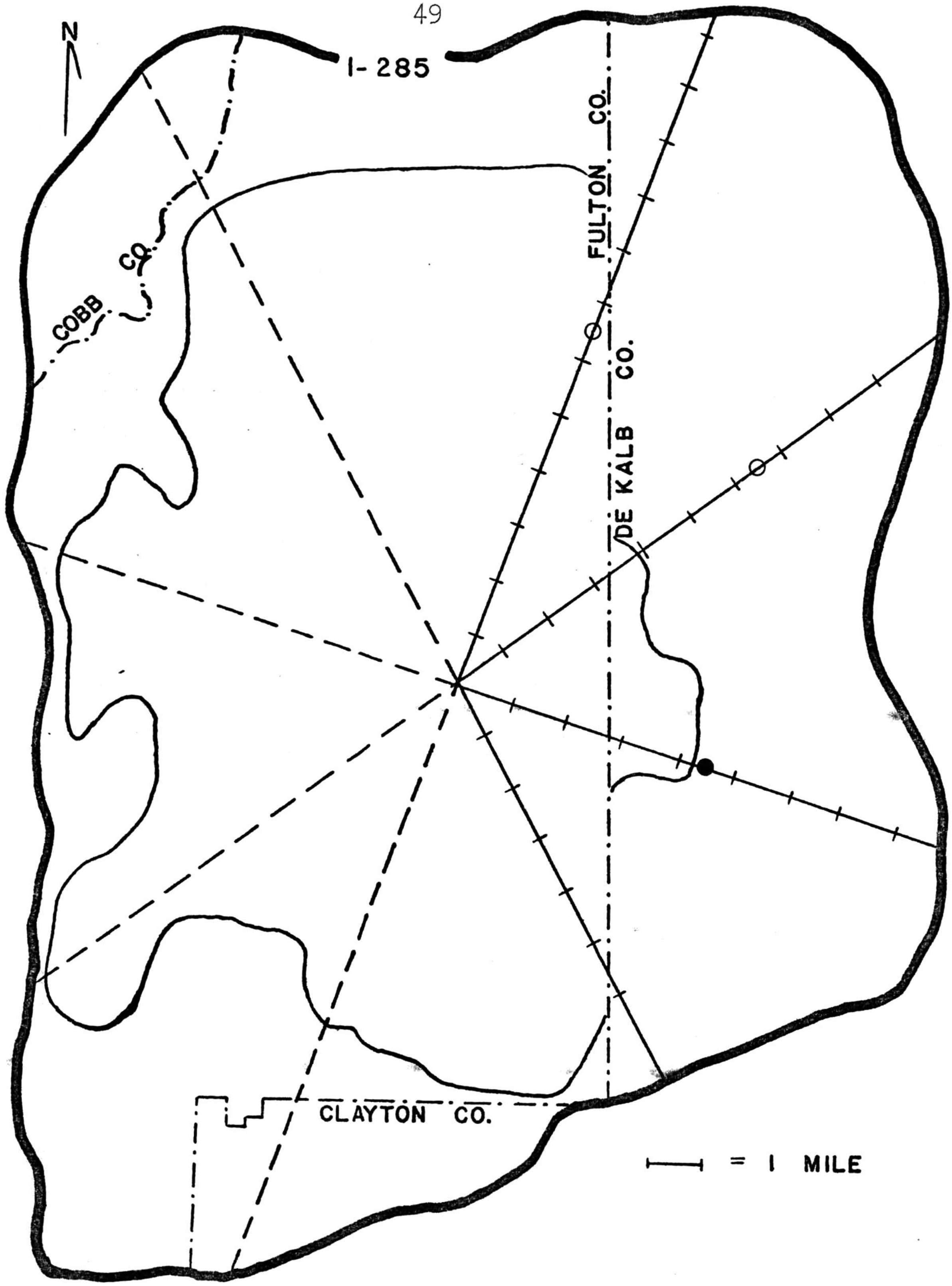

N
I-285
FULTON CO.
DE KALB CO.
COBB CO.
CLAYTON CO.
= 1 MILE

Fig. 17. The distribution of Parmelia tinctorum (o) and Parmeliopsis hyperopta (●) in eastern metropolitan Atlanta, as revealed by this study.

Legend:

Interstate 285 - "perimeter highway"

Atlanta city limits

County lines

Transects collected by R. A. Neal

Outline of transects collected by D. A. Fritchman

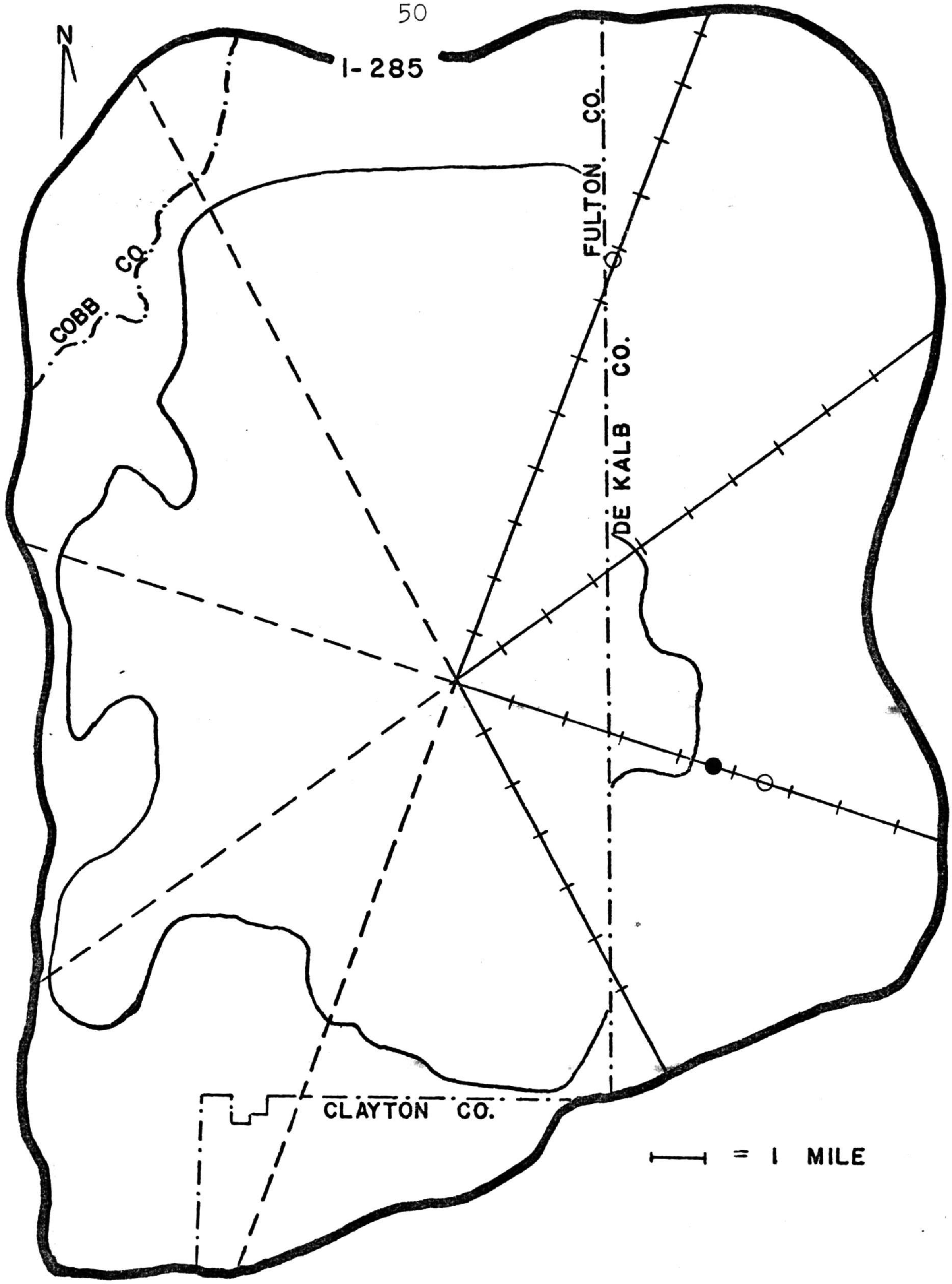

N
I-285
COBB CO.
FULTON CO.
DE KALB CO.
CLAYTON CO.
= 1 MILE

Fig. 18. The distribution of *Platismata glauca* (○) and *Physcia lacinulata* (●) in eastern metropolitan Atlanta, as revealed by this study.

Legend:

Interstate 285 - "perimeter highway"

Atlanta city limits

County lines

Transects collected by R. A. Neal

Outline of transects collected by D. A. Fritchman

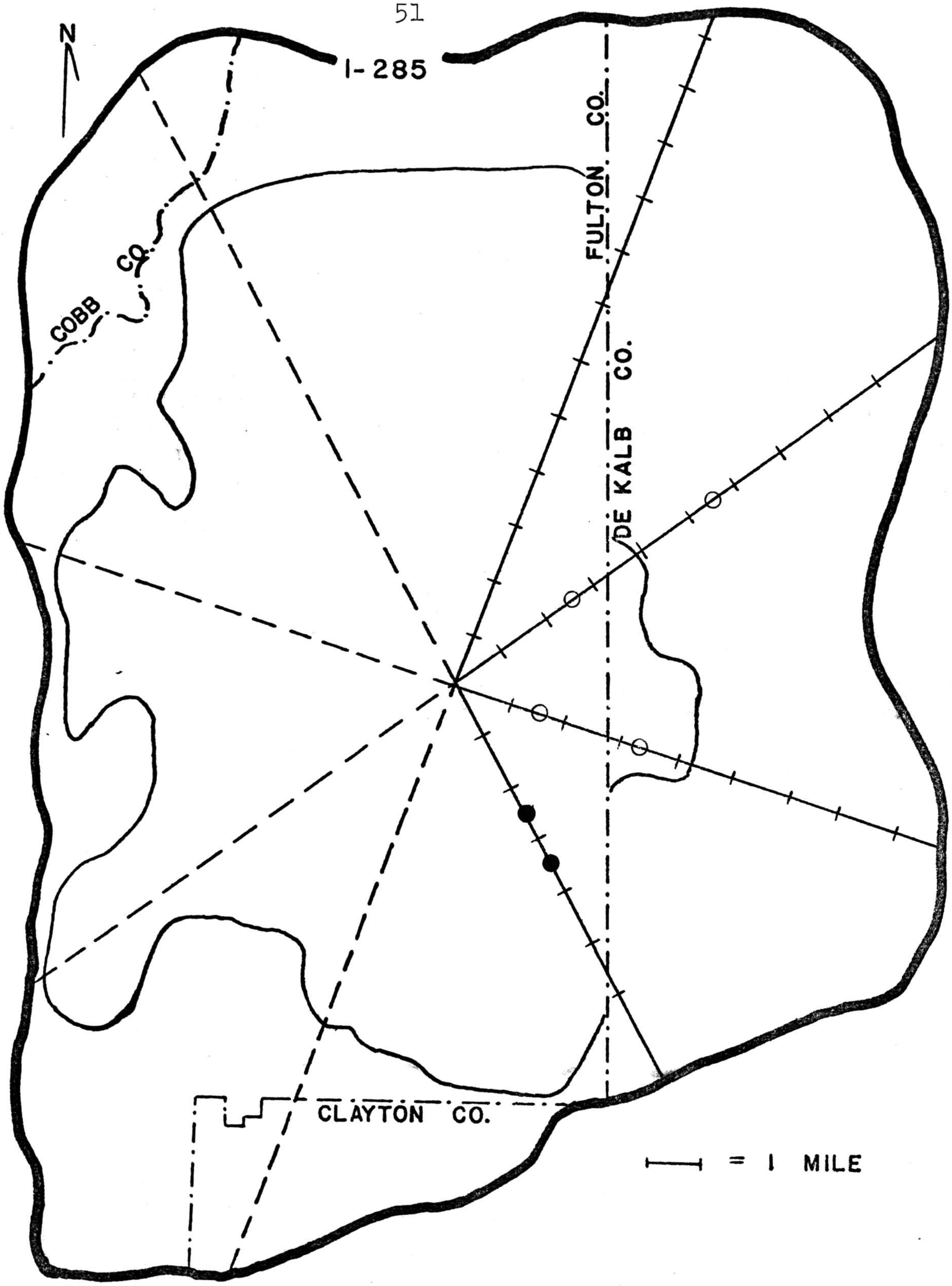

N
I-285
FULTON CO.
COBB CO.
DE KALB CO.
CLAYTON CO.
= I MILE

Fig. 19. The distribution of *Physcia millegrana* (○) and *P. tribacoides* (●) in eastern metropolitan Atlanta, as revealed by this study.

Legend:

Interstate 285 - "perimeter highway"

Atlanta city limits

County lines

Transects collected by R. A. Neal

Outline of transects collected by D. A. Fritchman

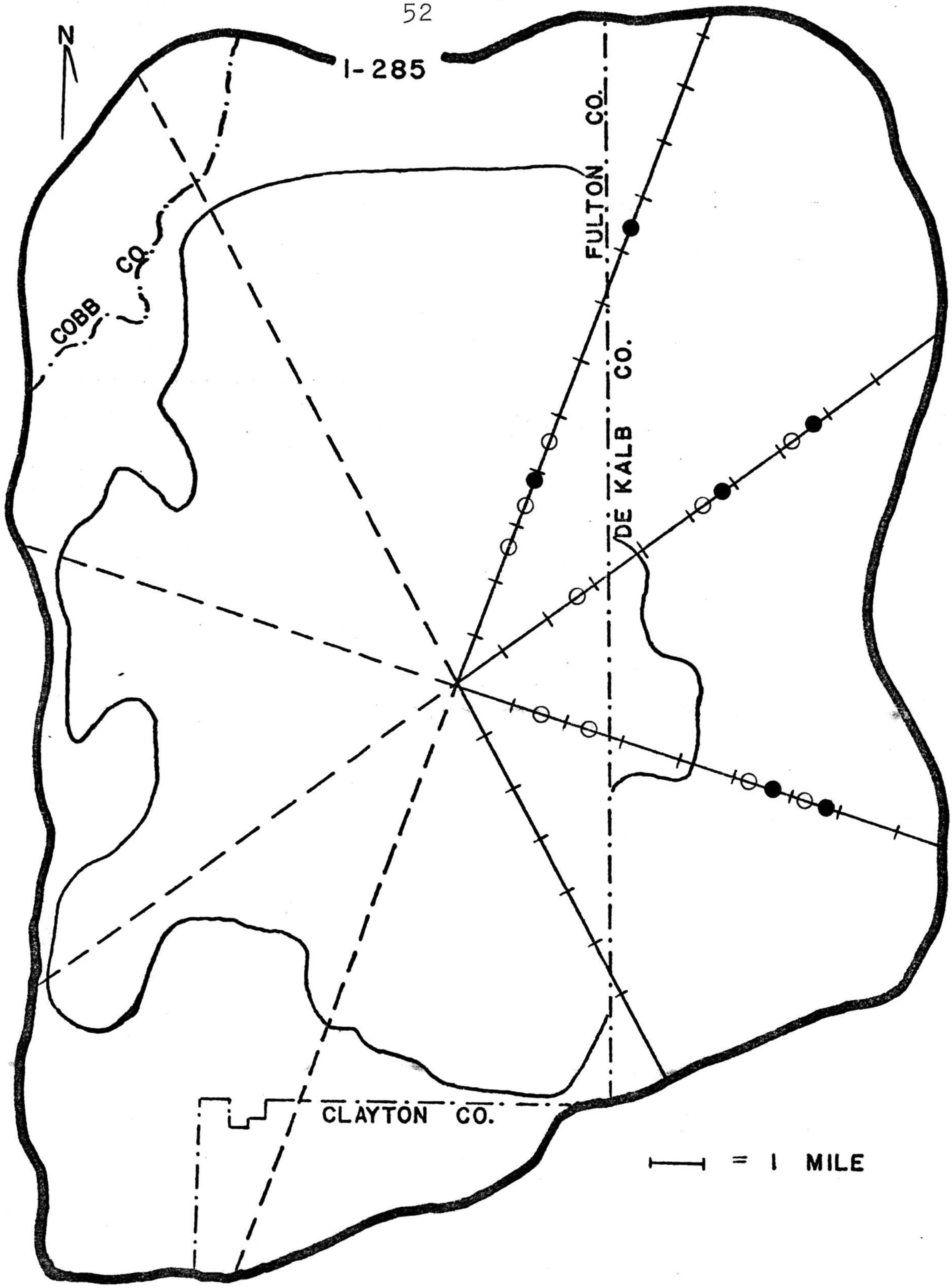

N
I-285
FULTON CO.
COBB CO.
DE KALB CO.
CLAYTON CO.
= I MILE

Fig. 20. The distribution of _Pyxine caesiopruinosa_ (●) and _P. sorediata_ (○) in eastern metropolitan Atlanta, as revealed by this study.

Legend:

Interstate 285 -- "perimeter highway"

Atlanta city limits

County lines

Transects collected by R. A. Neal

Outline of transects collected by D. A. Fritchman

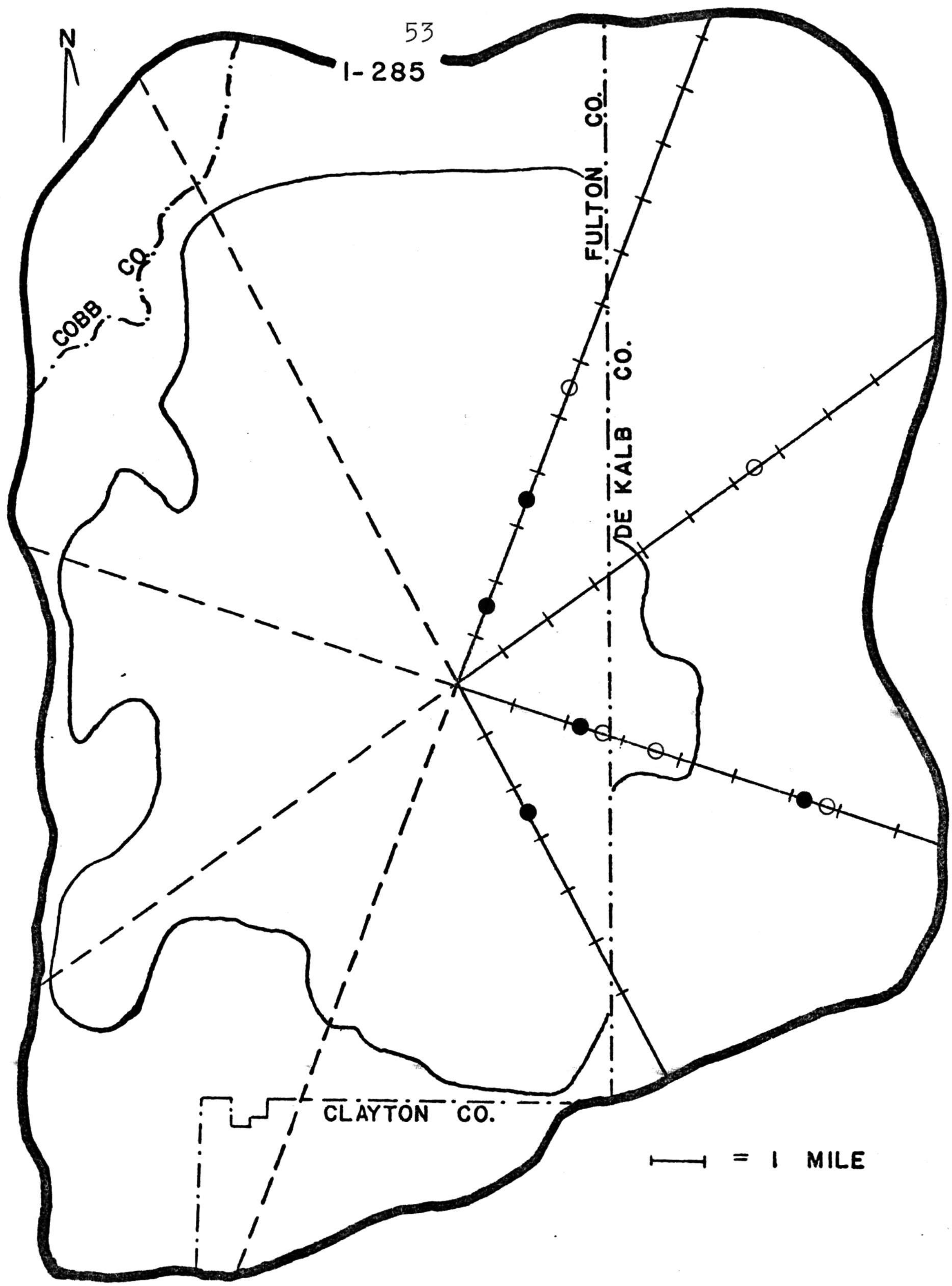

N
I-285
FULTON CO.
COBB CO.
DE KALB CO.
CLAYTON CO.
= 1 MILE

Fig. 21. The distribution of *Lobaria erosa* (o) and *L. pulmonaria* (●) in eastern metropolitan Atlanta, as revealed by this study.

Legend:

Interstate 285 - "perimeter highway"

Atlanta city limits

County lines

Transects collected by R. A. Neal

Outline of transects collected by D. A. Fritchman

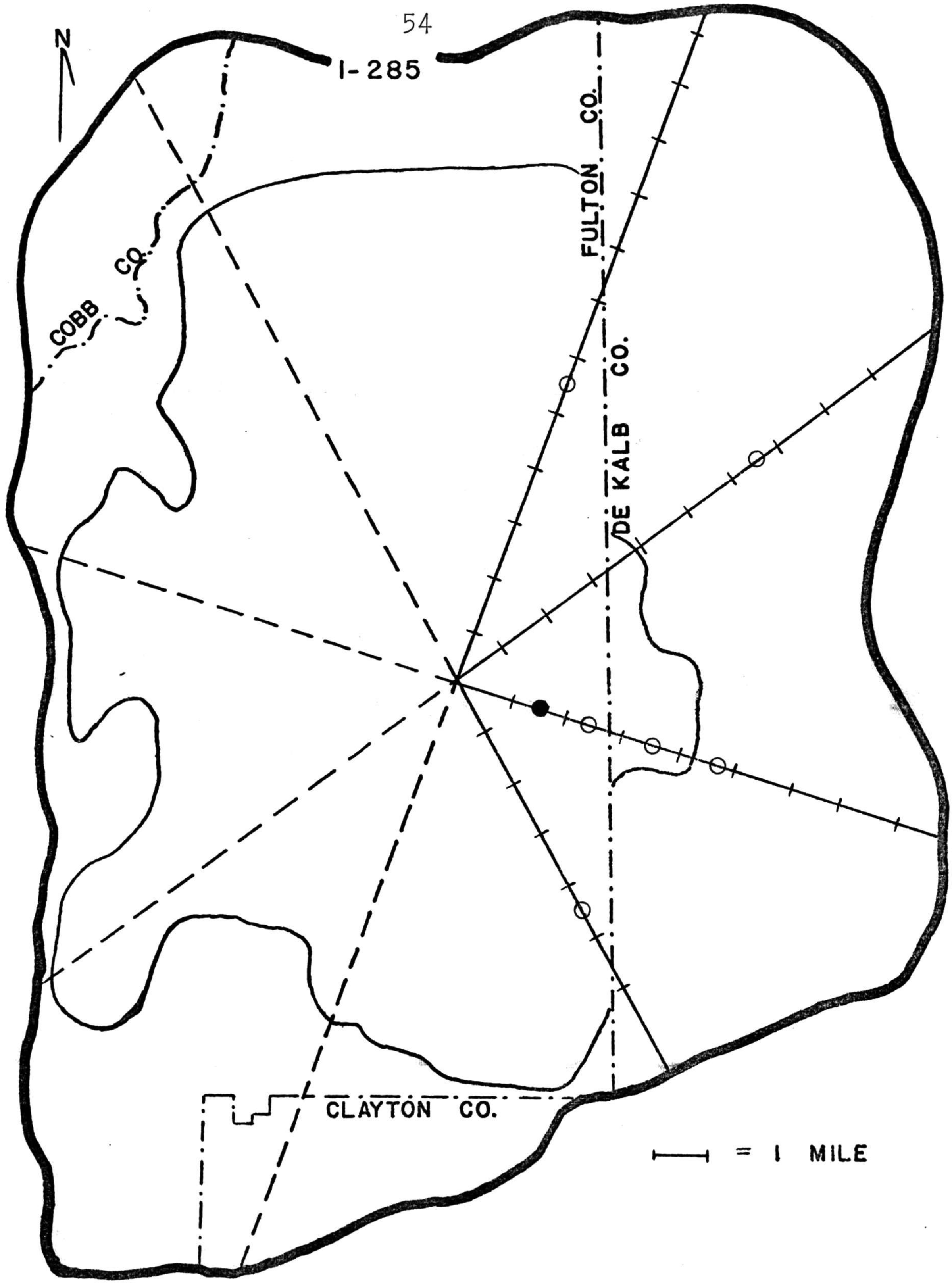

N
I-285
FULTON CO.
COBB CO.
DE KALB CO.
CLAYTON CO.
= 1 MILE

Fig. 22. The distribution of _Buellia_ sp. (o) and _Graphis_ sp. (●) in eastern metropolitan Atlanta, as revealed by this study.

Legend:

Interstate 285 - "perimeter highway"

Atlanta city limits

County lines

Transects collected by R. A. Neal

Outline of transects collected by D. A. Fritchman

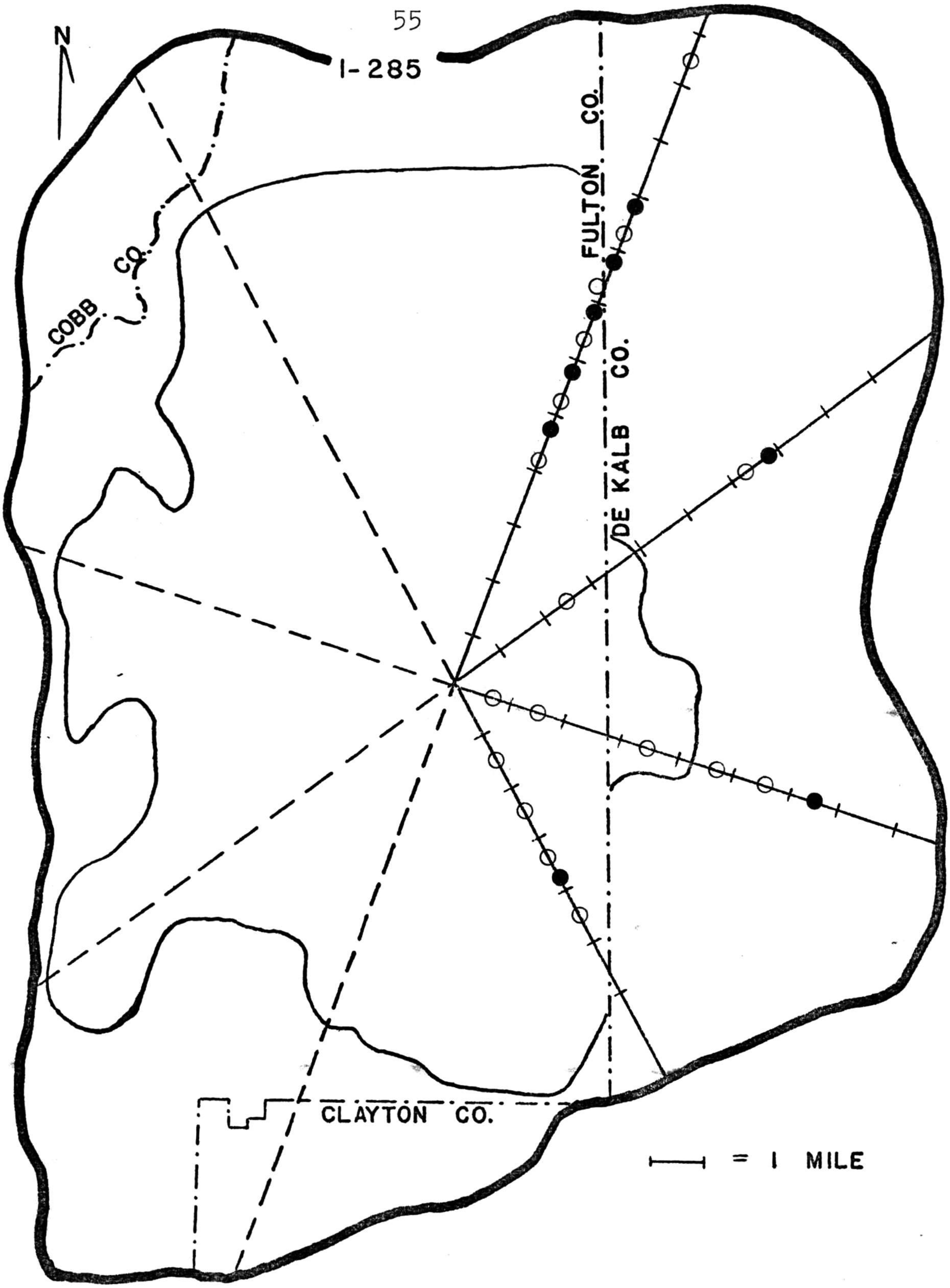

N
I-285
COBB CO.
FULTON CO.
DE KALB CO.
CLAYTON CO.
= I MILE

Fig. 23. The distribution of _Lecanora_ collection A (●) and _Lecanora_ collection B (o) in eastern metropolitan Atlanta, as revealed by this study.

Legend:

Interstate 285 - "perimeter highway"

Atlanta city limits

County lines

Transects collected by R. A. Neal

Outline of transects collected by D. A. Fritchman

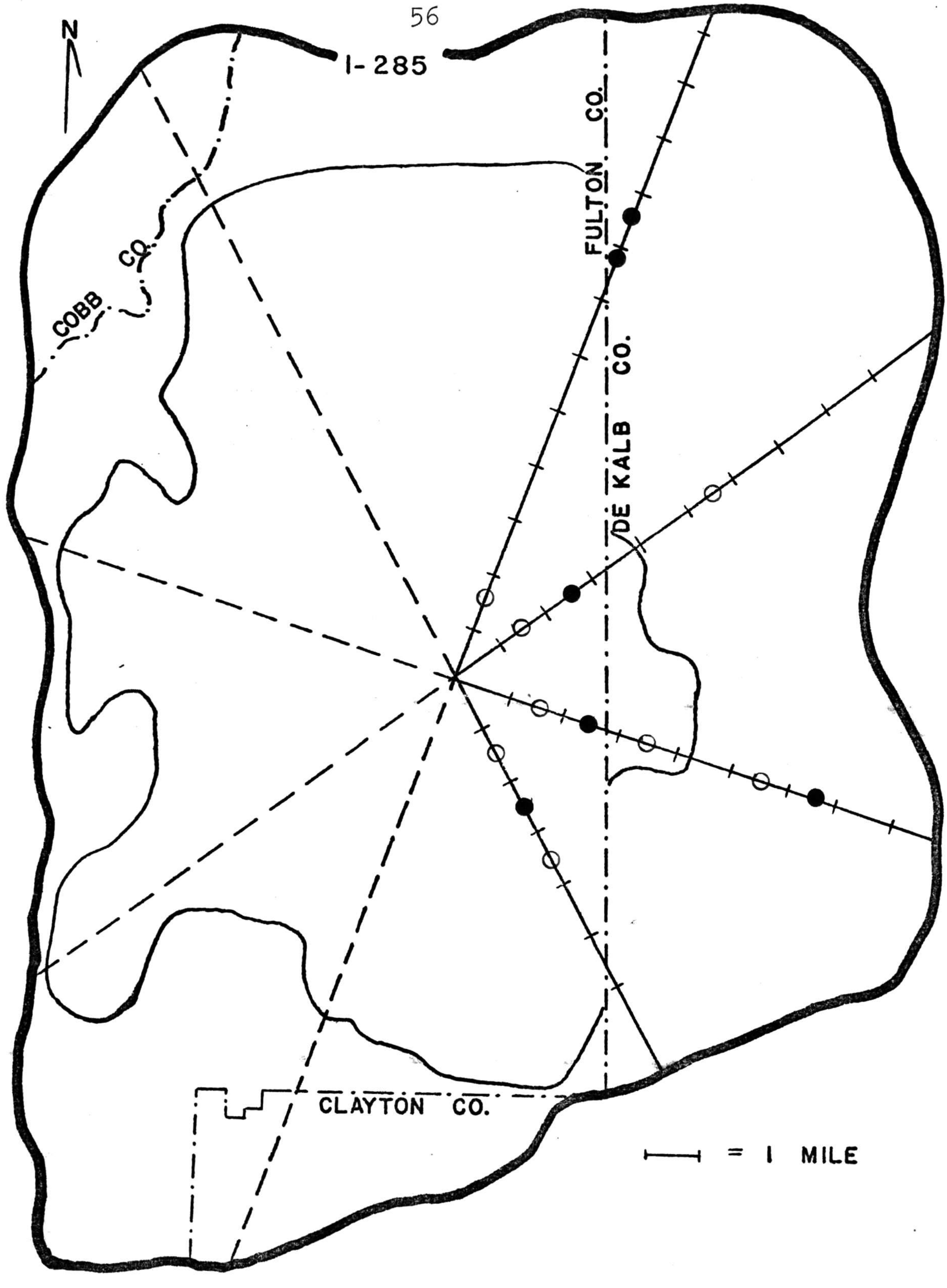

N
I-285
FULTON CO.
DE KALB CO.
COBB CO.
CLAYTON CO.
= 1 MILE

Fig. 24. The distribution of *Lecanora* collection C (●) and *Lecidia* collection A (o) in eastern metropolitan Atlanta, as revealed by this study.

Legend:

Interstate 285 - "perimeter highway"

Atlanta city limits

County lines

Transects collected by R. A. Neal

Outline of transects collected by D. A. Fritchman

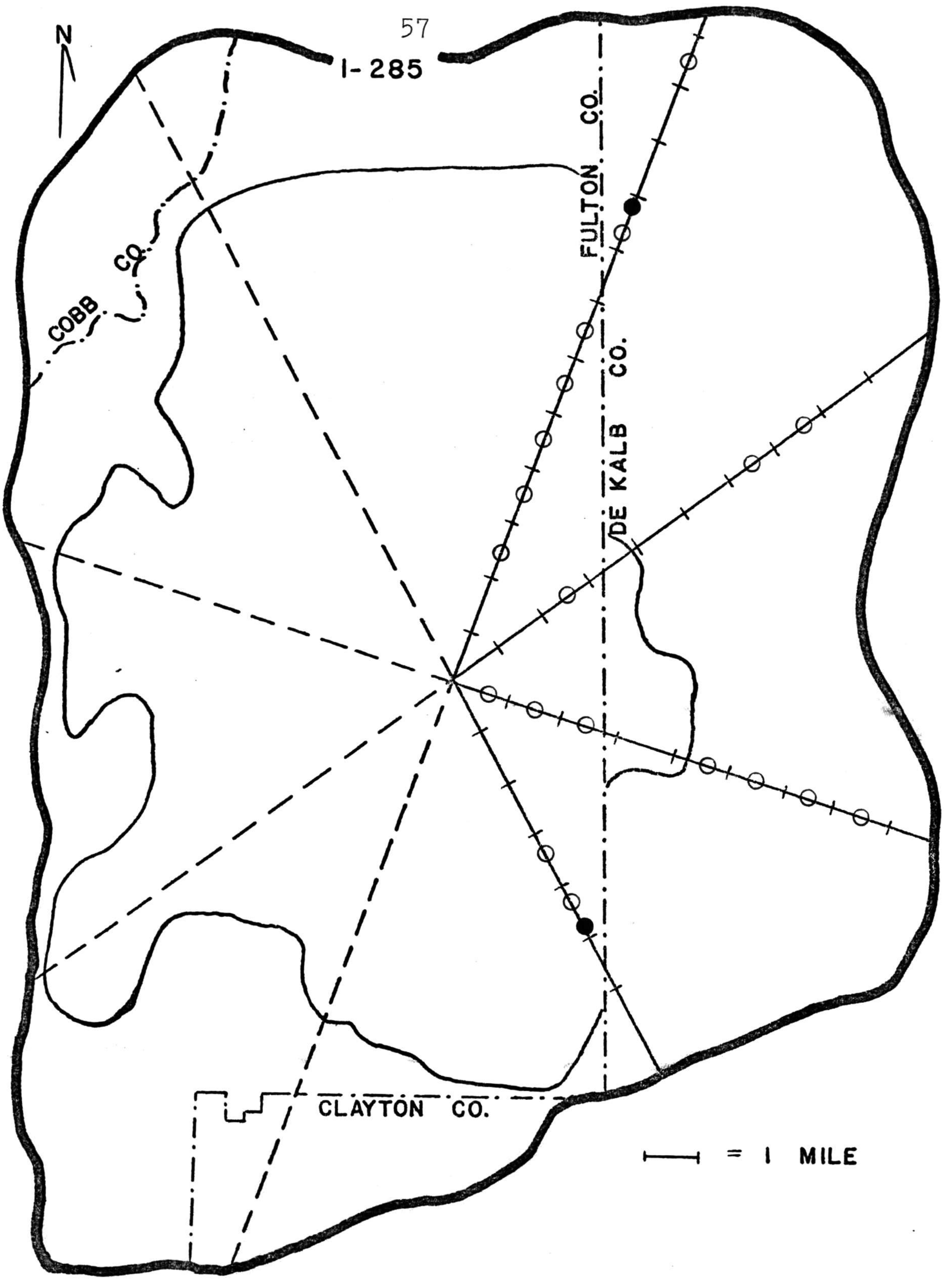

N
I-285
COBB CO.
FULTON CO.
DE KALB CO.
CLAYTON CO.
= 1 MILE

Fig. 25. The distribution of *Rinodina* collection A (●) and *Trypethelium* collection a (○) in eastern metropolitan Atlanta, as revealed by this study.

Legend:

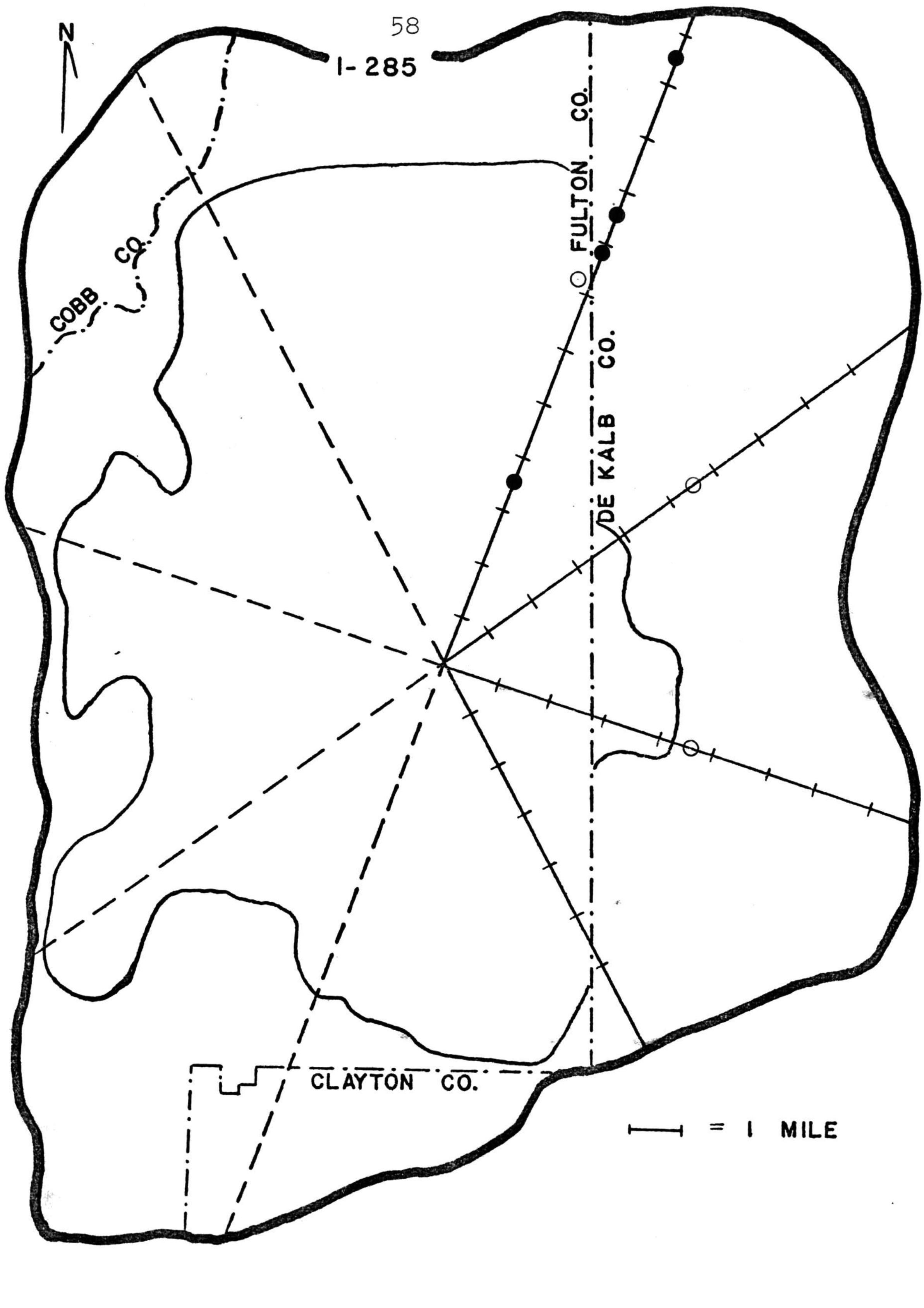
Interstate 285 - "perimeter highway"

Atlanta city limits

County lines

Transects collected by R. A. Neal

Outline of transects collected by D. A. Fritchman


N
I-285
FULTON CO.
COBB CO.
DE KALB CO.
CLAYTON CO.
= I MILE

of four miles from the city's center. Thirty-six (88%) of the species occurred at sites 6 miles from the city's center and 41 (97%) occurred at seven miles (Table 8). The data on the distribution of lichens on each transect, as shown in Tables 1-4, are summarized and averaged in Table 9 and reveal a peak of 13.3 species 7 miles from the city's center and a decrease in the number of species as you approach the "perimeter highway".

Crustaceous species, as mentioned before, were keyed only to genus. On account of this, a brief description of the morphological features of their thalli and the morphology of the fungal components reproductive structures is given in the Check-list. Also included in the Check-list is the number of sites each specific lichen occurred and the kind of tree or trees it was collected from. A list of all lichen collected in this survey is given in Table 10.

Table 9. Distribution of crustaceous and non-crustaceous lichens according to Transect.

	Distance from City's Center (miles)											
	1	2	3	4	5	6	7	8	9	10	11	12
Transect A	0	3[1]	10	10	9	10	12	17	11	0	0	4
Transect B	0	9	8	0	0	9	14	7	0			
Transect C	3	11	9	9	10	11	14	0				
Transect D	0	6	9	11	12	0						
Totals	3	29	36	29	31	30	40	24	11	0	0	4
Average[2]	3	7	9	9	10	10	13	12	11	0	0	4

[1]Each figure represents number of species found at corresponding collection site.

[2]Averages are calculated to the nearest whole number.

CHECK-LIST OF LICHEN SPECIES FOUND ON TREES IN THE EASTERN PART OF THE CITY OF ATLANTA

Non-Crustaceous Forms

1. *Anaptychia obscurata* (Nyl.) Vain.

   Collected at 1 site from an oak tree

2. *Anaptychia ravenelii* (Tuck.) Zahlbr.

   Collected at 3 sites from both oak and elm trees

3. *Anaptychia speciosa* (Wulf.) Mass.

   Collected at 2 sites from both oak and elm trees

4. *Anaptychia squamulosa* Degel.

   Collected at 1 site from an oak tree

5. *Candelaria concolor* (Dichs.) Stein

   Collected at 22 sites from both oak and elm trees

6. *Cetaria oakesiana* Tuck.

   Collected at 1 site from an oak tree

7. *Ceteria pinastri* (Scop.) S. Gray

   Collected at 1 site from an oak tree

8. *Cladonia apodocarpa* Robb.

   Collected at 5 sites from oak trees

9. *Parmelia aurulenta* Tuck.

   Collected at 2 sites from elm trees

10. *Parmelia caperata* (L.) Ach.

    Collected at 22 sites from both oak and elm trees

11. *Parmelia caroliniana* Nyl.

    Collected at 6 sites from both oak and elm trees

12. *Parmelia ceterata* Ach.

Collected at 11 sites from oak trees

13. *Parmelia confoederata* Culb.

Collected at 1 site from oak tree

14. *Parmelia crinita* Ach.

Collected at 2 sites from oak trees

15. *Parmelia dilatata* Vain.

Collected at 1 site from an oak tree

16. *Parmelia dissecta* Nyl.

Collected at 1 site from an oak tree

17. *Parmelia galbina* Ach.

Collected at 1 site from an oak tree

18. *Parmelia mellissii* Dodge

Collected from 1 site from an oak tree

19. *Parmelia michauxiana* Zahlbr.

Collected at 7 sites from both oak and elm trees

20. *Parmelia reticulata* Tayl.

Collected at 6 sites from both oak and elm trees

21. *Parmelia rudecta* Ach.

Collected at 22 sites from both oak and elm trees

22. *Parmelia scortella* Nyl.

Collected at 1 site from an oak tree

23. *Parmelia subtinctoria* Zahlbr.

Collected at 2 sites from oak trees

24. *Parmelia texana* Tuck.

Collected at 1 site from an oak tree

25. Parmelia tinctorum Nyl.

Collected at 2 sites from oak trees

26. Parmeliopsis hyperopta (Ach.) Arn

Collected at 1 site from an oak tree

27. Platismata glauca (L.) Culb. & Culb.

Collected at 4 sites from both oak and elm trees

28. Physcia lacinulata (Mull.) Arg.

Collected at 2 sites from oak trees

29. Physcia millegrana Degel.

Collected at 10 sites from both oak and elm trees

30. Physcia tribacoides Nyl.

Collected at 6 sites from both oak and elm trees

31. Pyxine caesiopruinosa (Nyl.) Imsh.

Collected at 5 sites from both oak and elm trees

32. Pyxine sorediata (Ach.) Mont.

Collected at 5 sites from oak trees

33. Lobaria erosa (Eshu.) Nyl.

Collected at 6 sites from oak and elm trees

34. Lobaria pulmonaria (L.) Hoffm.

Collected at 1 site from an elm tree

Crustaceous Forms

1. <u>Buellia</u> De Not.

   Description: Thallus very thin, reticulated and greenish grey in color; apothecia pitch black in color without a thalline margin; ascospores dark, uniseptate, 13-15μ long; ascus with 8 ascospores.

   Occurrence: collected at 17 sites from both oak and elm trees.

2. <u>Graphis</u> Adams

   Description: Cortex whitish to mineral grey, appearing to be continuous with the tree bark; apothecia buff-colored with a thalline margin; ascospores 5-7 septate, 30-45μ long, hyaline, ascus containing 8 ascospores.

   Occurrence: collected at 8 sites from oak trees.

3. <u>Lecanora</u> (Collection A) Ach

   Description: Cortex whitish to greenish grey, continuous with bark of tree; apothecia brown with a thin thalline margin; ascospores non-septate 5-10μ long, hyaline; ascus with 8 ascospores.

   Occurrence: collected at 6 sites on both oak and elm trees.

Lecanora (Collections A, B, and C) differ from each other in ascospore size and apothecial color to the extent that I separated them as different species.

4. *Lecanora* (Collection B)

   Description: Cortex distinctly greenish and powdery, somewhat elevated over the tree bark; apothecia light tan to buff-colored with a prominent thalline margin; ascospores non-septate, hyaline, 12-16μ long; ascus with 8 ascospores.

   Occurrence: collected at 8 sites from both oak and elm trees.

5. *Lecanora* (Collection C)

   Description: Thallus thick, cortex greenish grey; apothecia large (0.5-0.8 mm) and urn shaped, disc reddish brown; ascospores non-septate, 30-45μ long, dark in color; ascus with 8 ascospores.

   Occurrence: collected at 2 sites on oak trees.

6. *Lecidia* Ach.

   Description: Thallus thin; cortex deeply reticulate, greenish to mineral grey; apothecia large (0.5-0.7 mm) irregularly shaped with a light purple disc and white (non-thalline) margin; ascospores non-septate, hyaline, 20-30μ long; ascus with 8 ascospores.

   Occurrence: collected at 16 sites from both oak and elm trees.

7. Rinodina (Ach.) S. Gray

Description: Thallus somewhat raised above the tree bark, pustular, greenish grey in color; cortex smooth, slightly shiny; apotheciawwith a black disc and a thalline margin; ascospores non-septate, dark, 15-20µ long; ascus with 8 ascospores.

Occurrence: collected at 4 sites from oak trees.

8. Trypethelium Spreng.

Description: Thallus thick in areas around fruiting bodies - thin otherwise; cortex greenish grey with yellow ostioles from embedded ascocarps; ascocarps locular with no distinct walls; ascospores non-septate, thick-walled, 30-40µ long; ascus with 8 ascospores.

Occurrence: collected at 3 sites from oak trees.

Table 10. Listing of all lichen genera and species reported in this study.

A. Non-Crustaceous Forms

Anaptychia obscurata
Anaptychia ravenelii
Anaptychia speciosa
Anaptychia squamulosa
Candelaria concolor
Cetaria oakesiana
Cetaria pinastri
Cladonia apodocarpa
Lobaria erosa
Lobaria pulmonaria
Parmelia aurulenta
Parmelia caperata
Parmelia caroliniana
Parmelia ceterata
Parmelia confoederata
Parmelia crinita
Parmelia dilatata
Parmelia dissecta
Parmelia galbina
Parmelia mellissii
Parmelia michauxiana
Parmelia reticulata
Parmelia rudecta
Parmelia scortella
Parmelia subtinctoria
Parmelia texana
Parmelia tinctorum
Parmeliopsis hyperopta
Physcia lacinulata
Physcia millegrana
Physcia tribacoides
Platismata glauca
Pyxine caesiopruinosa
Pyxine sorediata

B. Crustaceous Forms

Buellia sp.
Graphis sp.
Lecanora sp. A
Lecanora sp. B
Lecanora sp. C
Lecidia sp.
Rinodina sp.
Trypethelium

CHAPTER V

DISCUSSION AND CONCLUSIONS

When lichen distribution, as found in this study of the eastern portion of metropolitan Atlanta, is compared with lichen distribution in studies from other urban areas, the results generally agree. The center of a metropolitan area is congested on account of the large buildings built close together, heavy street traffic, and commonly, in prior years, the heavy rail traffic. These conditions lead to highly unfavorable conditions for trees and other forms of plant life. Congested conditions begin to diminish as one moves away from the central district of a large city and ecologic conditions that favor the growth of plants correspondingly improve. Lichen distribution has been known to follow such a pattern with the central part of the city being a virtual lichen desert. Lichen abundance generally increases as the distance from the city's center increases. This pattern may be modified, however, by the presence of pollution sources in other parts of the city.

This study shows that a similar kind of a pattern in lichen distribution also occurs in the eastern half of metropolitan Atlanta. A new factor affecting lichen distribution, viz., the geographical location of the city, is thought to operate in metropolitan Atlanta in addition to the factors considered in other studies of this nature. Atlanta is the southern most city subjected to a study of this type; therefore, I believe that its southern latitude interjects a set of ecologic factors, influencing lichen distribution, that were not present in other urban settings where studies have been made.

Atlanta is located at the foot of the Blue Ridge Mountains at an elevation of 1,000 feet; its terrain is consequently rolling and hilly. Such a topography results in numerous depressions which may become "frost pockets" where localized thermal inversions could occur. These inversions would prevent the upward flow of polluted air and thereby in effect fumigate the vegetation of the site. This is believed to be the probable explanation for decreases in the number of lichens at specific sites on a transect where an increase in the number of lichens species would normally have been expected. Site 8 (Table 2) may represent such an area since no pollution sources are known to be in the vicinity.

Atlanta has milder weather than any city previously studied. The close proximity of the Atlantic Ocean and Gulf of Mexico tends to temper the summer heat and winter cold. The mountain range to the north acts as a barrier to the cold arctic air masses and results in winters being relatively mild. Such mild winter temperatures produced by these effects decrease the need for excessive heating. This lower heat requirement in turn effectively reduces the amount of sulfur dioxide emitted into the atmosphere during the season when lichens are relatively active. The absence of high sulfur dioxide concentrations (exact figures are not available at this time) should and probably does enhance the lichen population and distribution in eastern metropolitan Atlanta.

Although Atlanta is located near the humid subtropical climate belt and averages 48 inches of rain a year, dry periods of several weeks to a month are not uncommon (U. S. Dept. of Commerce Publication, 1970). LeBlanc has speculated that alternating periods of dry and wet conditions are more harmful to lichens than long severe dry periods. If these speculations are correct, then the lichen bionta of Atlanta could be significantly affected by this factor.

Humidity levels are presumed to play a role in lichen distribution. The average relative humidity in Atlanta is slightly over 70%. This is a higher level than that reporeed by Brodo (1968) for the Long Island area. Such a humidity level would seem to enhance the conditions that would favor lichen occurrence and survival. In a related observation made during the course of this study I noted that there appears to be no change in the vertical distribution of _P. caperata_ and _P. rudecta_ on trees in this locality. This vertical distribution of these species is contrary to the observation of Brodo for he reported that in the Long Island area these species were restricted to the lower areas of tree trunks. Brodo suggests that lichen distribution on a tree responds to xeric conditions in such a fashion that certain species, normally found at breast height, are restricted to the base of the tree where the relative humidity is higher.

Due to the absence of analysis equipment in metropolitan Atlanta there is a lack of scientific data on prior prevailing pollution conditions. Published reports (U. S. Dept. of HEW, 1970) offer only theoretical data on pollution levels. These data have been of little value in assessing the effects pollution may have had on the lichen population in the metropolitan area. At the present time, 10 Continuous Air Monitoring Program stations are being installed. This will provide useful data for future studies of this nature.

Eastern metropolitan Atlanta is less industrialized than the western section and therefore offers new point sources of pollution. Probably, it is due to this absence of major pollution sources that accounts for the gradual increase in the number of lichen species found along the transects studied as the distance from the city center increases. These findings agree with those reported by Brodo (1966).

The major pollutants in metropolitan Atlanta are carbon monoxide and particulate matter. Their specific effects on lichen thalli have not been fully studied as yet, therefore valid correlations cannot be made at this time. The synergistic action of nitric oxides and sulfur dioxide is known to have a more detrimental effect on vascular plants than either of the pollutants alone. The same effect may produce damage to the lichen thallus. Although Barkman (1969) has suggested that carbon monoxide does damage lichen thalli, he has not discussed the possible effects of a synergistic action of the two pollutants. The "perimeter highway," while not an old source of pollution, according to the observations made in this study, appears to decrease the population of lichens on the trees near it. It is possible that the high concentrations of nitric oxides produced by vehicles traveling on the "perimeter highway" act with the sulfur dioxide already in the atmosphere to affect lichens in that area. At this point, however, such a notion is simple conjecture and is without any supporting evidence.

During the course of this study, a long time resident of the city related to me that 30 years ago, when coal was the major source of fuel in Atlanta, the pollution was so bad that you could not see the tops of the tallest downtown buildings. Since no pollution data is available from that period, it can be only speculated that the lichen population of Atlanta was probably dealt a severe blow 30-40 years ago and that current lichens are exhibiting the effects of both city induced xeric conditions and long term exposure to low levels of pollutants.

The general absence of trees in the first one mile interval (Sites 1, 13, 22, 30), where only one site (#22) was established, does not allow for a valid judgment as to the presence of a "lichen desert" existing in eastern metropolitan Atlanta. Indeed, the collection of 29 lichen samples in the second interval (as compared to 3 in the first interval) would suggest that no "lichen desert" exists in Atlanta (Table 9).

Fritchman (1971) reports finding a suitable site (trees present) that had no lichens at all. This site was near the Fulton County Airport, and Fritchman speculates that pollution from the airport probably created this "lichen desert".

The characteristic gradual increase in the number of lichen species shown by each transect does, however, indicate that the city environment has some effect on the lichens found here. Exactly what effect is not known. The high percentage of sterile thalli found supports, in part, the suggestion of LeBlanc (1969) that pollution causes morphological changes in the lichen thalli. The mechanism whereby these changes are brought about are not known. In addition, the observations of thallus death at a large number of sites (60%) is also indicative of pollution effects on lichens.

Based on the data collected from the survey of lichen distribution in eastern metropolitan Atlanta, the following conclusions appear valid.

1. That the geographic location of Atlanta is a primary factor affecting the distribution of lichens within the area.
2. That no lichen desert, due to the general city environmental effect, exist in the eastern half of metropolitan Atlanta.
3. That the lichen population of the area is presently being affected by (a) xeric conditions both city induced and natural, and (b) by atmospheric pollutants.
4. That the perimeter highway effectively reduces the lichen population on trees near it, possibly by the synergistic action of nitric oxides and sulfur dioxide.

CHAPTER VI

SUMMARY

Forty-two species of lichens representing 18 genera are reported from samples collected along designated transects established in eastern metropolitan Atlanta. Thirty-four of the species reported are non-crustaceous (foliose or fruticose forms) and 8 are crustaceous. Only one of the 34 non-crustaceous species reported, _Cladonia apodocarpa_, was found to be fruticose.

Data from the distribution of lichens in the area studied indicate that (1) no lichen deserts exist in eastern metropolitan Atlanta, (2) the geographic location of Atlanta is a primary factor affecting lichen distribution and well-being in the city, (3) both xeric condition and atmospheric pollutants are presently affecting the lichen population in the area, and (4) the perimeter highway affects the lichen population on trees near it, possibly by the synergistic action of nitric oxides and sulfur dioxide.

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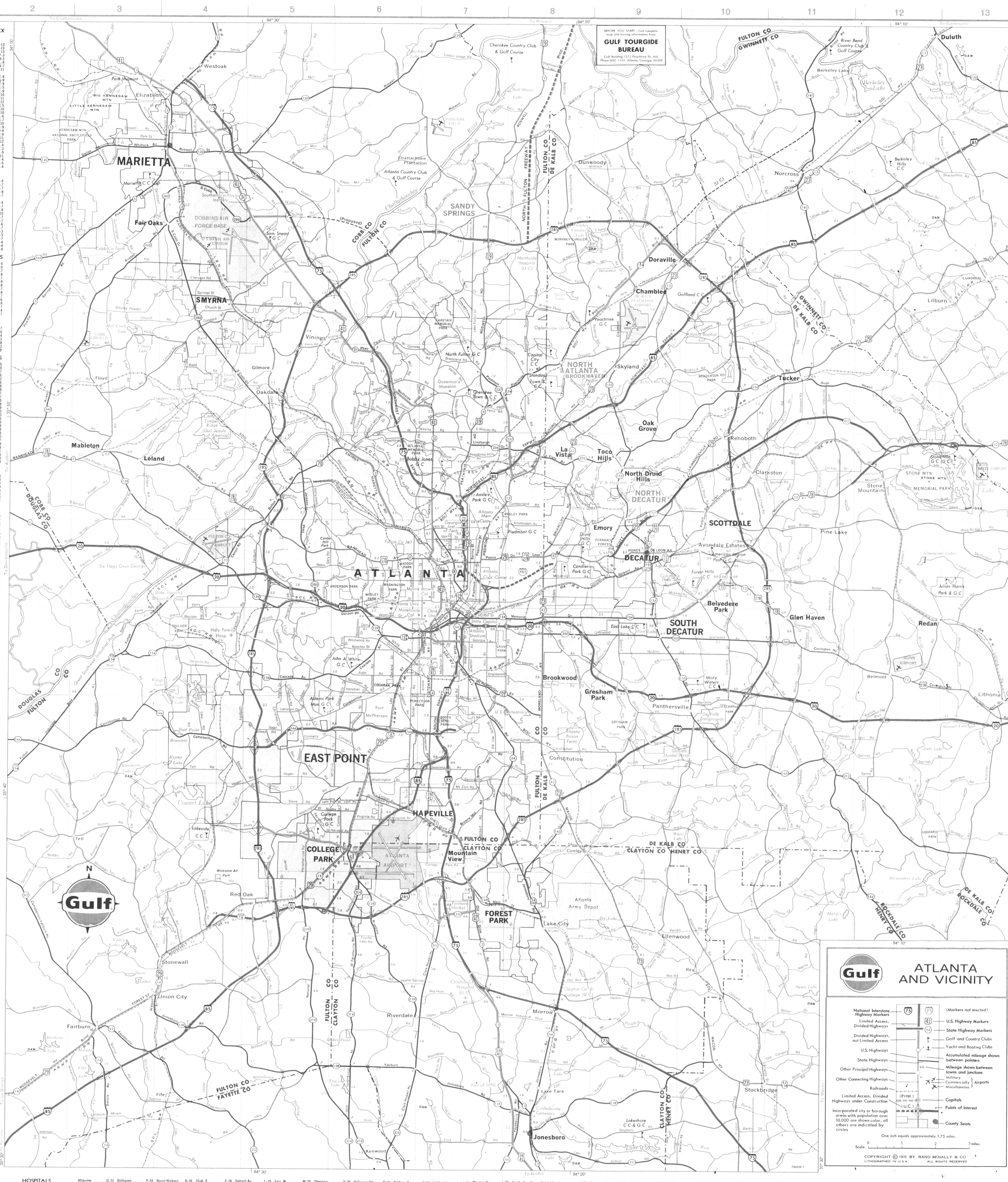
APPENDIX

(City Map Showing Transects and Sites)

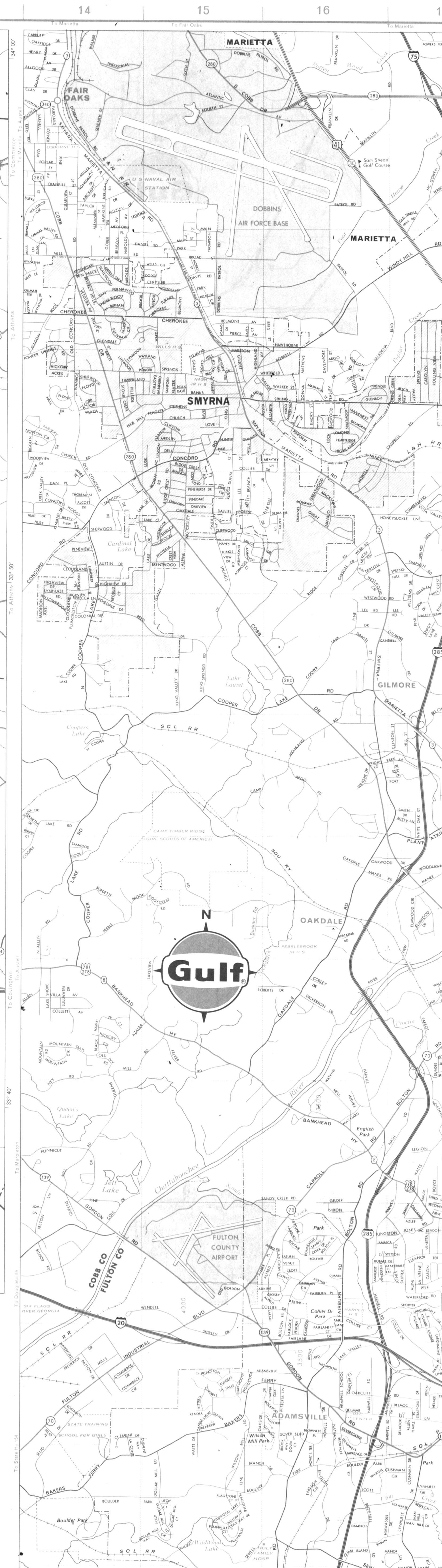
ATLANTA & VICINITY INDEX

CITIES AND TOWNS · POINTS OF INTEREST · UNIVERSITIES AND COLLEGES · HOSPITALS · GOLF AND COUNTRY CLUBS · AIRPORTS · PARKS · PRINCIPAL ROADS

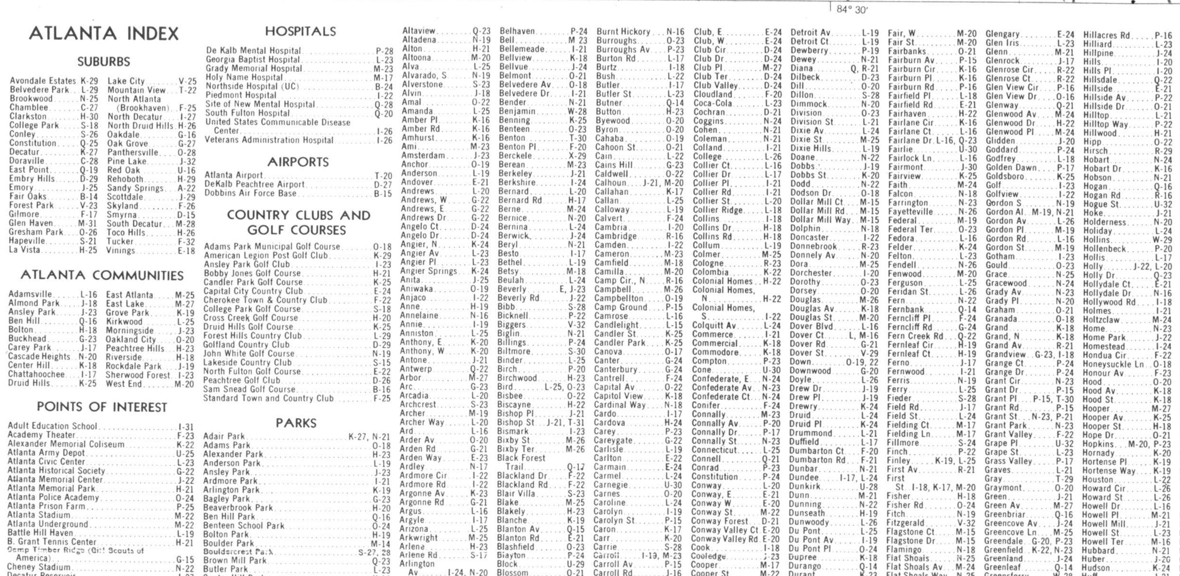


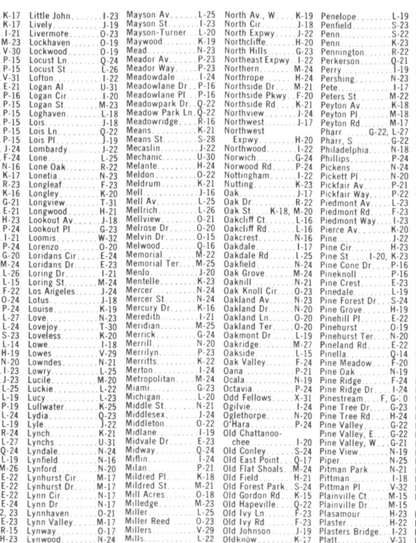
ATLANTA INDEX

SUBURBS · ATLANTA COMMUNITIES · POINTS OF INTEREST · UNIVERSITIES AND COLLEGES · HIGH SCHOOLS AND JR. HIGH SCHOOLS · HOSPITALS · AIRPORTS · COUNTRY CLUBS AND GOLF COURSES · PARKS · CEMETERIES · STREETS



STOP AT THE SIGN OF THE ORANGE DISC





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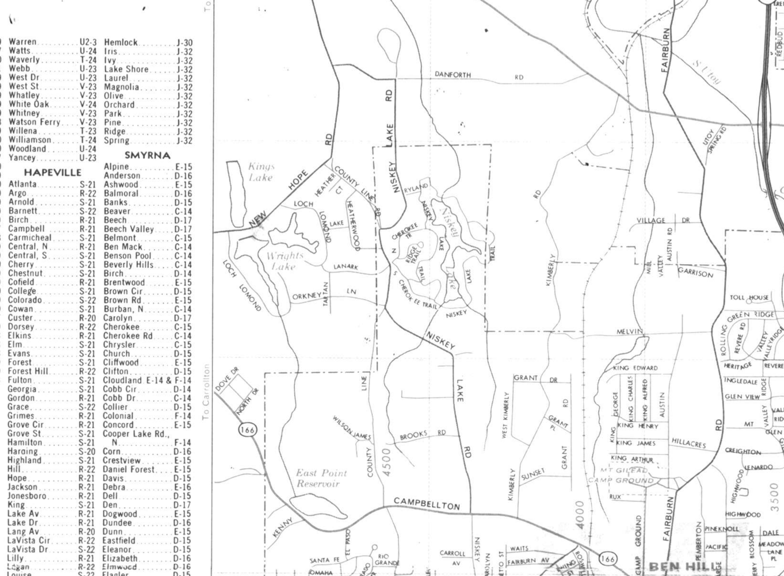

ATLANTA — Skyline of Atlanta showing in foreground the $18 million Atlanta Stadium, home of the Braves and Falcons. The stadium seats 50,670 for baseball and 58,850 for football.

WHAT TO SEE IN ATLANTA AND VICINITY

Atlanta Historical Society (1753 Peachtree St., N.E.). The Margaret Mitchell Memorial Library honors the author of "Gone with the Wind." The society also houses the Atlanta Civil War Round Table Museum.

Atlanta International Raceway (24 miles south on U.S. 41). Home of Grand National Circuit stock car races.

Atlanta Memorial Arts Center (1280 Peachtree St.). Spectacular new center opened in the fall of 1968 includes 1,848-seat Symphony Hall, the Alliance Theater, Studio Theater, Walter Hill Auditorium, the High Museum of Art, and the Atlanta School of Art.

Atlanta Stadium. The Atlanta Braves play heads-up baseball in the stadium. Football and soccer games are also played here.

Catherine Hughes Waddell Gallery (In Trevor Arnett Library at the Atlanta University Center). Contemporary Negro art exhibits.

Cyclorama (In Grant Park). Light and sound effects and a three-dimensional set of the climactic Civil War Battle of Atlanta. The great circular painting surrounding the set is 50 feet high, 400 feet around, and weighs 18,000 pounds.

Emory Museum (Bishop's Hall at Emory University). Ancient artifacts of the Near East and relics of American Indians.

Fort Walker (In Grant Park). The Confederate battery has been set up as it was during the Siege of Atlanta. Nearby is the "Texas," railroad locomotive, used during the Civil War Andrews Raid.

Georgia Institute of Technology (North Ave. at Luckie St., N.W.). One of the leading technological institutes in the U.S. and the largest in the South.

Georgia State Farmers' Market (10 miles south on State 331, off Int. 75). This 146-acre market is the largest farmers' market in the nation.

Historic Lamp Post (N.E. corner of Whitehall and Alabama Sts., S.E.). The first shell from Federal artillery to slam into downtown Atlanta during the Civil War burst against this post. It is now restored as a memorial.

Rhodes Memorial Hall (1516 Peachtree St., N.W.). This copy of a Bavarian castle has beautiful stained glass windows showing the rise and fall of the Confederate States of America.

Robert Burns Cottage (Alloway Place, S.E.). The poet's birthplace in Alloway, Scotland, has been reproduced.

Six Flags Over Georgia (Int. 20 West at Chattahoochee River). Seventy-five rides, shows, and attractions tell the story of the Empire State of the South while entertaining visitors.

State Capitol (At Washington and Mitchell). Gold from Georgia's gold fields at Dahlonega gilds the dome of the Capitol. The Georgia State Museum of Science and Industry, on the 4th floor, displays wildlife and fossils.

Stone Mountain Memorial State Park (16 miles east of Atlanta on U.S. 78). Enormous equestrian figures of Jefferson Davis, Robert E. Lee, and Stonewall Jackson are being cut into the face of Stone Mountain, the world's largest granite monolith. Lee's sword alone is 50 feet long. A Swiss cable car takes visitors to the mountain top, and the "Robert E. Lee" Show Boat takes them around Stone Mountain Lake. Passengers on the Stone Mountain Railroad take part in a restaging of the "Great Locomotive Chase" of Civil War renown. The 12-story, 610-bell carillon is the largest in the world. There also are a game ranch where tame animals roam free, an Old South plantation and formal garden, and the Battlarena, a scale relief map of Georgia depicting Sherman's march to the sea. There is a family camping ground on the shores of the lake.

Wren's Nest (1050 Gordon St., S.W.). Joel Chandler Harris, author of the "Uncle Remus" stories, lived in this gabled house. The briar patch of "Brer Rabbit" is behind the house.

DOWNTOWN ATLANTA POINTS OF INTEREST

1A..Alexander Memorial Coliseum....R-30
1AA.American Motor Hotel.........U-30
2A..Atlanta Biltmore Hotel.........S-30
3A..Atlanta Cabana Motor Hotel....S-31
4A..Atlantan Hotel..............U-30
5A..Atlanta Stadium.............W-30
6A..Atlanta University............V-28
1B..Bank of Georgia Bldg.........U-30
1C..Carnegie Library.............U-30
2C..Central Jr. High School........V-30
3C..Cheney Stadium..............X-31
4C..City Buildings...............V-30
5C..City Hall...................V-30
6C..Civic Center................T-31
7C..Clark University.............V-28
8C..Cox Carlton Hotel............S-31
9C..Crawford W. Long Hospital.....T-31
10C..Cyclorama.................X-32
1D..Dinkler Plaza Hotel..........U-30
1E..Emory Univ. School of Dentistry.T-31
2E..Exhibition Hall (Civic Center)...T-31
1F..Federal Building.............U-30
2F..Federal Reserve Building......U-30
3F..First National Bank..........V-30
4F..Fox Theatre.................S-31
5F..Fulton Co. Court House........V-30
6F..Fulton Co. Juvenile Court......W-30
7F..Fulton National Bank Bldg......U-30
1G..Georgia Baptist Hospital.......U-32
2G..Georgia Hotel...............U-30
3G..Georgia Institute of Technology.S-30
4G..Georgia State Capitol.........V-30
5G..Georgia State College.........V-31
7G..Georgian Terrace Hotel........S-31
8G..Grady Memorial Hospital.......V-31
9G..Grant Field.................S-30
10G..Greyhound Bus Station........U-30
1H..Heart of Atlanta Motel........U-31
2H..Henry Grady Hotel............U-30
3H..Historic Lamp Post...........V-30
4H..Hoke-Smith Technical School..W-31
5H..Holiday Inn.................U-31
6H..Howard High School...........U-32
7H..Howard Johnson's Motor Lodge.X-30
1I..Imperial Hotel...............T-31
2I..Interdenominational Theological Seminary....................V-28
1L..Life of Georgia Tower.........T-30
2L..Loew's Grand Theatre.........U-31
1M..Marriott Motor Hotel.........U-31
2M..Martin Cinerama.............T-31
3M..Massey Jr. College...........U-30
3MA.Merchandise Mart............U-30
4M..Morehouse College...........V-28
5M..Morris Brown College.........U-28
1O..O'Keefe High School..........S-30
1P..Parliament House Motel.......U-31
2P..Peachtree Manor Hotel........S-31
3P..Pocket Theatre..............T-31
4P..Post Office (New)............V-30
5P..Post Office (Old)............U-30
1R..Regency Hyatt House Hotel.....U-30
2R..Rialto Theatre...............U-30
3R..Roxy Theatre................U-30
1S..St. Joseph Infirmary..........U-31
2S..Southern College of Pharmacy..U-30
3S..Spellman College............W-28
4S..State Agricultural Building.....V-30
5S..State Archives Building.......W-31
6S..State Highway Dept...........V-30
7S..State Office Buildings........V-30
1T..Tech Motel.................T-30
2T..Terminal Station............V-30
3T..Trailways Bus Station........U-30
4T..Travelodge Motel............T-31
1U..Underground Atlanta.........V-30
2U..Union Station...............U-30
1Y..Yaarab Temple..............S-32
2Y..YMCA.....................U-30
3Y..YWCA.....................U-31